ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. L. No. 24. New York, December 10, 1903.

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THE WORK OF THE MADISON PARK AND PLEASURE DRIVE ASSOCIATION, MADISON, WIS.

By W. D. Taylor,* M. Am. Soc. C. E.

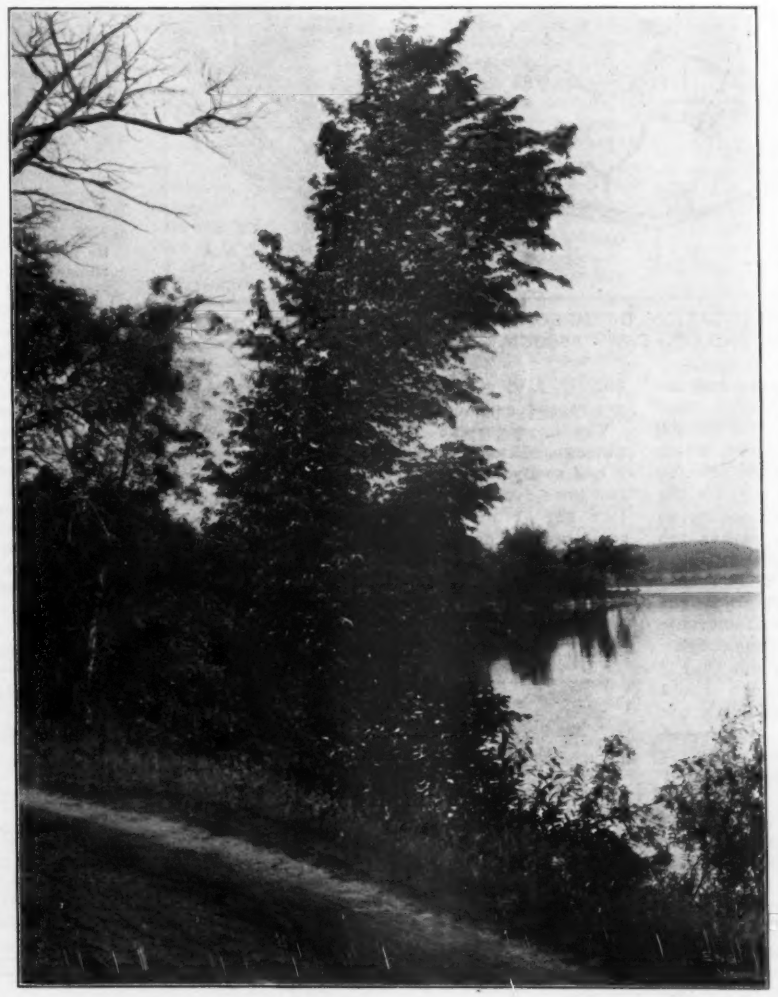
It is seldom possible to induce a large part of a whole community to act in accord, the well-to-do and the poor together, in expending large sums of money for purely esthetic purposes, but the success in this direction of an organization at Madison, Wis., which has no other purpose than a public-spirited desire to beautify the surroundings of a city, already one of the most beautiful in the country, is somewhat phenomenal; and the engineering work necessary for the carrying out of the plan of this organization cannot fail to be of interest to engineers.

As shown by the accompanying map, Madison is built on a narrow strip of land a half-mile or more in width between two beautiful fresh water lakes, Mendota and Menona. The map also shows the Yahara River, connecting the two lakes. It is a shallow stream running through marsh lands, but its waters are perfectly clear and fresh throughout the year. The width of the stream varies from 60 to 100 ft., and the depth ranges from 2 to 5 ft. Across the Yahara River there are four railroad bridges; also four highway bridges belonging to the city. The country on each side of the stream being flat and low, the bridges were built with very small clearance above mean water level in the stream. This clearance was as small as 2 ft. 9 ins. in the case of the heavy double-track through plate girder of the Northwestern road's main line between Chicago and the Twin Cities, and the clearance of seven of the eight bridges was less than 5 ft.

The surface of Lake Mendota covers 15 square miles, and of Lake Menona 6 square miles. The surface of Lake Menona is between 4 and 5 ft. lower than the surface of Lake Mendota. Nearly all of the difference of level occurs at the upper end of the Yahara River, where a mill utilized the water power until a few years ago, when it burned down. Since then the city has acquired the rights to the stream and has built and maintained a dam at the same site in order to control the level of the upper lake, which is largely used by pleasure craft.

Thus, although the city is provided with two beautiful lakes and there are many handsome residences overlooking each, there has been heretofore no communication between the two by the water craft extensively used for fishing and pleasure on both lakes, the dam, the difference of level, and the low bridges, preventing.

The Madison Park and Pleasure Drive Association was organized July 10, 1894, to promote the acquisition and extension of parks and driveways in and about the capital city of the State. Though the principal object of this article is to describe the improvement of the Yahara River, it is interesting to note here that this public-spirited association had received contributions for its primary purposes, from its organization to March, 1903, of more than $55,000. The subscribers for the year 1902 were 662 in number, and the amount subscribed for that year $5,238. The fact that 370 of these subscriptions were for only $5 each bears testimony to the class of citizens interested in the work of the association. The work accomplished up to the beginning of the present year was the acquisition and improvement of 14 acres of land within the city, now called Tenney Park; the construction and maintenance of macadamized driveways within the city and along the shores of the lakes; and the planting of trees and shrubs along the drives. At the present time the association has under its charge 32 acres in parks and about 25 miles of improved driveways without the city proper. The association has planted to date in the parks and along the drives about 16,000 shrubs, 4,000 deciduous trees and 600 vines. The location and extent of the drives under the control of the association is shown by the accompanying plan.



THE SHORE PATH, LAKE MENDOTA, GROUNDS OF THE UNIVERSITY OF WISCONSIN.

In an address at the annual meeting, in the spring of 1902, the president of the association projected a scheme for the association to undertake the improvement of the Yahara River. It was proposed to clean out and deepen the river bed by dredging, to raise the bridges high enough to allow any craft now in use on either lake to pass through the river, to secure the land on each side of the stream for driveways which should be elevated above the marshes by the material dredged from the bottom of the river, and to build a lock at the upper end of the Yahara River of sufficient size to pass any craft likely to be placed on the lakes. During the winter just passed an engineer located at the State University at Madison made, free of charge, preliminary surveys, estimates and plans for the work. At a meeting of some thirty citizens, in January of the present year, at the home of an ex-cabinet officer living in Madison, the plans were thoroughly outlined and discussed and then approved. Later, at a meeting of the directors of the association, a committee was appointed to go to Chicago and confer with the presidents of the railway companies, to try and induce them to assist in the scheme to the extent of raising their tracks and bridges to the required elevation at their own expense. This committee submitted to the railways a copy of the bill that it was proposed to introduce in the legislature requiring the railways and the city of Madison

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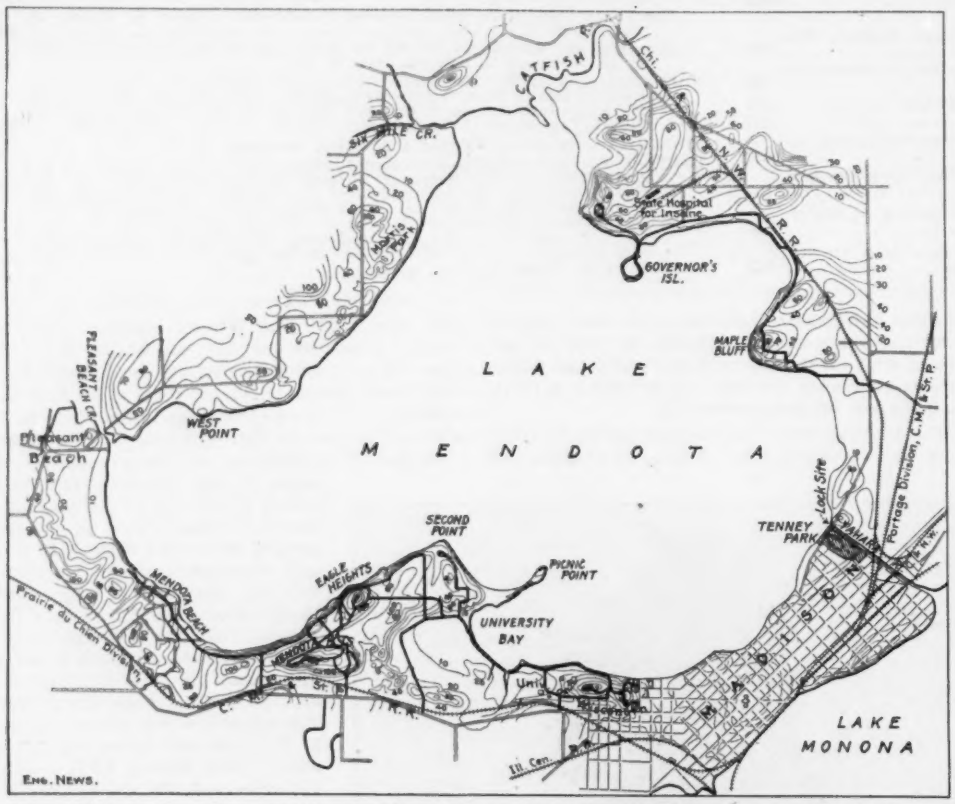
to elevate all the bridges over the stream so as to give at all points at least 8 ft. of vertical clearance between the mean water surface and the bottom of the bridges, and 30 ft. of horizontal clearance between abutments or supports.

Although four main line tracks, one Y track, several warehouses, sidings and spurs, a coal storage plant, a pumping station, and an interlocked crossing were affected by the proposed change, all these properties were controlled by



MAP OF MADISON, WIS., SHOWING LOCATION OF IMPROVEMENTS MADE BY THE MADISON PARK AND DRIVEWAY ASSOCIATION.

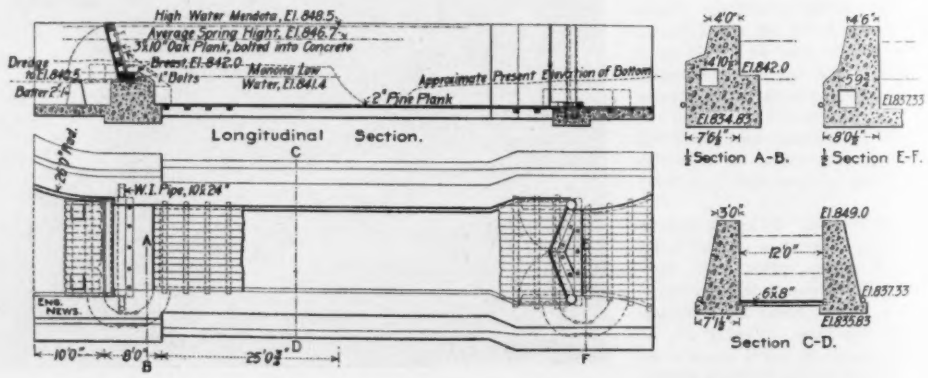
two roads, the Chicago & Northwestern and the Chicago, Milwaukee & St. Paul railways. That they should voluntarily expend between $30,000 and $40,000 upon a scheme of this nature, which would not have a direct bearing upon the revenue of their roads and which would not improve the physical condition of their properties so far as their operation was concerned, but rather the contrary, was somewhat of a bold proposition to present to the managing officers of these roads; but the attitude assumed by these officers at the outset toward this proposition was characteristic of far-sighted American railway management. The committee was assured by both roads that if the association and the city of Madison would carry out their parts of the proposed work the roads would co-operate with them and would elevate their tracks. Under the proposed arrangement the city was to elevate three of its bridges and entirely rebuild a fourth, and to acquire whatever land was necessary for the construction of the drives on each side of the river that the association could not get donated. The association was to clean out and dredge the stream, construct the drives and build the lock at the head of the river. For carrying out its part of the arrangement it was estimated that the Driveway Association would need for this purpose $15,000, and the bill was introduced in the legislature requiring the railways and the city of Madison to elevate their bridges over the Yahara on or before May 1, 1904, provided that before the law should become effective the president of the association should file a statement under oath with the Governor of the State showing to the satisfaction of the Governor that responsible citizens of Madison and others had subscribed for the use of the association in the Yahara River improvement the sum of $15,000. This bill met with no opposition, but rather the support of the railways and of the city of Madison, and became a law on March 28, 1903. That day the president of the association made under oath before the Governor the statement that not $15,000, but $20,615, had been subscribed to the association by citizens of Madison for this work.

Contracts for dredging the stream were soon let and the work is now under way. The channel is being made 9 ft. or more deep for a width of 50 ft. from one lake to the other.

The concrete masonry lock, which has been completed, was built under contract at a price of $6,000. A view and detailed drawings of the lock are reproduced herewith.

The improvement fell quite heavily upon the Chicago, Milwaukee & St. Paul Railway because it had newly constructed pile trestle bridges on its two lines over the Yahara, which will have to be torn out at once to be replaced by permanent structures. The roads promptly began the work of elevating their tracks and have maintained their attitude of encouraging the enterprise. The president of the Northwestern road is quoted as having said to some of the members of the association, "I do not think you yourselves fully appreciate how much good you are doing your city."

The cost of the Yahara River improvement to the association, the city and the railways cannot be less than $65,000, and will probably amount to $80,000 before the work is all completed.



PLAN AND SECTION OF CONCRETE LOCK FOR SMALL CRAFT, YAHARA RIVER, MADISON, WIS.

SLIDE RULES FOR THE MACHINE SHOP AS A PART OF THE TAYLOR SYSTEM OF MANAGEMENT.*

By Carl G. Barth,† M. Am. Soc. M. E.

In his paper on "Shop Management," read at the Saratoga meeting of the society in June last, Mr. Fred. W. Taylor referred to certain slide rules that had been invented and developed under his supervision and general guidance, by means of which it becomes a comparatively simple matter to determine that feed and speed at which a lathe or kindred machine tool must be run in order to do a certain piece of work in a minimum of time.

These slide rules were also mentioned by Mr. H. L. Gantt in his paper "A Bonus System of Rewarding Labor" (New York meeting, December, 1901, Engineering News, Dec. 12, 1901), as being at that time in successful use in the large machine shop of the Bethlehem Steel Co., and reproductions of a number of instruction cards were therein presented, the dictated feeds and speeds of which had been determined by means of these slide rules.

Mr. Taylor early set about making experiments with a view to obtaining information in regard to resistances in cutting steel with edged tools, and also the relations that exist between the depth of cut and feed taken to the cutting speed and time that a tool will endure; and he advanced far enough along these lines in his early position as engineer for the Midvale Steel Co. to make systematic and successful use of the information obtained; but as this, of course, was confined to tempered carbon tools only, it was not applicable to the modern high-speed steel, so that the invention and introduction of this steel called for new experiments to be made.

These were first undertaken under Mr. Taylor's directions at Bethlehem, so far as the cutting of steel alone was concerned; and later on at the works of William Sellers & Co., Inc., of Philadelphia, at which place the writer spent fifteen months in going over these experiments again, on both steel and cast iron, and with tools of a variety of shapes and sizes, and for which nearly 25 tons of material were required.

However, it is not the writer's intention at this time, to give an account of these experiments, or of the results obtained and conclusions drawn from them, but merely to give some idea of the slide rules on which these have been incorporated, and by means of which a most complex mathematical problem may be solved in less than a minute.

He will also confine his attention to the most generally interesting of these slide rules; that is, the slide rules for lathes, and he will take for an example an old style belt-driven lathe, with cone pulley and back gearing.

Considering the number of variables that enter into the problem of determining the most economical way in which to remove a required amount of stock from a piece of lathe work, they may be enumerated as follows:

I. The size and shape of the tools to be used.
II. The use or not of a cooling agent on the tool.
III. The number of tools to be used at the same time.
IV. The length of time the tools are required to stand up to the work (Life of Tool).
V. The hardness of the material to be turned (Class Number).
VI. The diameter of this material or work.
VII. The depth of the cut to be taken.
VIII. The feed to be used.
IX. The cutting speed.
X. The cutting pressure on the tool.
XI. The speed combination to be used to give at the same time the proper cutting speed and the pressure required to take the cut.
XII. The stiffness of the work.

*From a paper presented at the New York meeting of the American Society of Mechanical Engineers.

†Consulting Engineer, 1600 Hamilton St., Philadelphia, Pa.

All of these variables, except the last one, are incorporated in the slide rule, which, when the work is stiff enough to permit of any cut being taken that is within both the pulling power of the lathe and the strength of the tool, may be manipulated by a person who has not the slightest practical judgment to bear on the matter; but which as yet, whenever the work is not stiff enough to permit of this, does require to be handled by a person of a good deal of practical experience and judgment.

However, we expect some day to accumulate enough data in regard to the relations between the stiffness of the work and the cuts and speeds that will not produce detrimental chatter, to do without personal judgment in this matter also, and we will at present take no notice of the twelfth one of the above variables but confine ourselves to a consideration of the first eleven only.

Of these eleven, all except the third and tenth enter into relations with each other that depend only on the cutting properties of the tools, while all except the second, fourth and ninth also enter into another set of relations that depends on the pulling power of the lathe, and the problem primarily solved by the slide rule is the determination of that speed-combination which will at the same time most nearly utilize all the pulling power of the lathe on the one hand, and the full cutting efficiency of the tools used on the other hand, when in any particular case under consideration values have been assigned to all the other nine variables.

If our lathe were capable of making any number of rev-

View of Yahara River Concrete Lock Under Construction; Looking Towards the Lake.

olutions per minute between certain limits, and the possible torque corresponding to this number of revolutions could be algebraically expressed in terms of such revolutions, then the problem might possibly be reduced to a solution by ordinary algebraic methods, of two simultaneous equations containing two unknown quantities; but as yet no such driving mechanism has been invented, or is ever likely to be invented, so that, while the problem is always essentially the solution of two simultaneous equations, or sets of relations between a number of variables, its solution becomes necessarily a tentative one; or, in other words, one of trial and error, and involving an endless amount of labor, if attempted by ordinary mathematical methods; while it is a perfectly direct and remarkably simple one when performed on the slide rule.

The slide rule method of solution may, however, also be employed for the solution of numerous similar problems that are capable of a direct and perfect algebraic solution; and it will, in fact, be best first to exhibit the same in connection with the simplest imaginable problem of this kind.

In the first place, the solution of two simultaneous equations may be graphically effected by representing each of them by a curve whose coördinates represent possible values of the two unknown quantities or variables, for then the coördinates of the point of intersection of these curves will represent values of the unknown quantities that satisfy both equations at the same time.

Example 1. Thus, if we have $y + x = 12$ and $y - x = 3$, these equations are respectively represented by the two straight lines AB and CD in Fig. 1; and as these intersect at a point (1) whose coördinates are $x = 4\frac{1}{2}$ and $y = 7\frac{1}{2}$, these values will satisfy both equations at the same time.

Example 2. Suppose again that we have $x.y = 18$ and $\frac{y}{x} = 3$, and these equations are respectively represented by the equilateral hyperbola EF and the straight line GH; and the coördinates to the point of intersection of these (2) being respectively $x = 2.45$ and $y = 7.35$, these values will satisfy both equations at the same time.

Example 3. Similarly, if we have $y - x = 3$ and $y.x = 18$, these equations are respectively represented by the straight line CD and the equilateral hyperbola EF; and the coördinates to the point of intersection of these (3) being $x = 3$ and $y = 6$, these values will satisfy both equations at the same time.

The slide rule method of effecting these solutions—to the consideration of which we will now pass—will readily be seen to be very similar in its essential nature to this graphical method, though quite different in form.

In Fig. 2 is shown a slide rule by means of which may be solved any problem within the range of the rule of the general form: "The sum and difference of two numbers being given, what are the numbers?"

The rule is set for the solution of the case in which the sum of the numbers is 12 and their difference 3, so that we may write

$$y + x = 12 \text{ and } y - x = 3,$$

which are the same as the equations in example 1 above.

In the rule, the upper fixed scale represents possible values of the sum of the two numbers to be found, for which the example under consideration gives $y + x = 12$, opposite which number is therefore placed the arrow on the upper slide.

The scale on this slide represents possible values of the lesser of the two numbers (designated by x) and the double scale on the middle fixed portion of the rule represents posible values of the greater of the two numbers (designated by y); and these various scales are so laid out relatively to each other, and to the arrow referred to, that any two coincident numbers on these latter scales have for their sum the number to which this arrow is set; in this case accordingly 12.

The bottom fixed scale on the rule represents possible values of the difference of the two numbers, in this case 3, opposite which number is therefore placed the arrow on the bottom slide of the rule, the scale on which also represents possible values of the lesser of the two numbers, x; and the double fixed scale in the middle of the rule representing as already pointed out, possible values of y, the whole is so laid out that any two coincident numbers on these latter scales have for their difference the number to which this arrow is set; in this case accordingly 3.

Fixing now our attention on any number on the double y scale in the middle of the rule, we first note the values coincident to it in the two x scales on the slides; and this done, we readily discover in which direction we must move along the first scale in order to pick out that value of y which has the same value of x coincident with it in both x scales. For the case under consideration this value of y is $7\frac{1}{2}$, and the coincident value in both scales is $4\frac{1}{2}$. Evidently, therefore, $y = 7\frac{1}{2}$ and $x = 4\frac{1}{2}$ are the numbers sought.

In the same manner we make a slide rule for the solution of the general problem: "The product and quotient of two numbers being given, what are the numbers?"

Such a rule would differ from the above described rule merely in having logarithmic scales instead of plain arithmetic scales.

By the combined use of both arithmetical and logarithmetic scales we may even construct rules for a similar solution of the general problems: "The sum and product, or the sum and quotient, or the difference and product, or the difference and quotient, of the two numbers being given, what are the numbers?" and a multiplicity of others; and the writer ventures to suggest that slide rules of this kind, and some even simpler ones, might be made excellent use of in teaching the first elements of algebra, as they would offer splendid opportunities for illustrating the rules for the operations with negative numbers, which are such a stumbling block to the average young student.

We now have sufficient idea of the mathematical principles involved, for a complete understanding of the working of the slide rule whose representation forms the main purpose of this paper.

This slide rule, in a somewhat ideal form in so far as it is made out for neither steel nor cast-iron, but for an ideal metal of properties between these two, is illustrated in Fig. 3. It will be seen to have two slides in its upper section and three in its lower section, and is in so far identical with the rules made for the Bethlehem Steel Co., while in the rules more recently made it had been found possible and convenient to construct it with only two slides in the lower section also.

It is shown arranged for a belt-driven lathe (No. 43*) with five cone-steps, which are designated respectively by the numbers 1, 2, 3, 4, 5, from the largest to the smallest on the machine. This lathe has a back gear only, and the back gear in use is designated by the letter A, the back gear out by the letter B. It also has two counter shaft speeds, designated respectively by S and F, such that S stands for the slower, F for the faster of these speeds.

The "Speed Combination" 3—A—S thus designates—to choose an example—the belt on the middle cone step, the back gear in, and the slow speed of the countershaft; and similarly, the combination 1—B—F designates the belt on the largest cone step on the machine, the back gear out, and the fast speed of the countershaft; and so on.

The double, fixed scale in the middle of the rule (marked "Feed") is equivalent to the y scale of the rule in Fig. 2, and the scales nearest to this on the slides on each side of it (marked "Speed Combination for Power and for

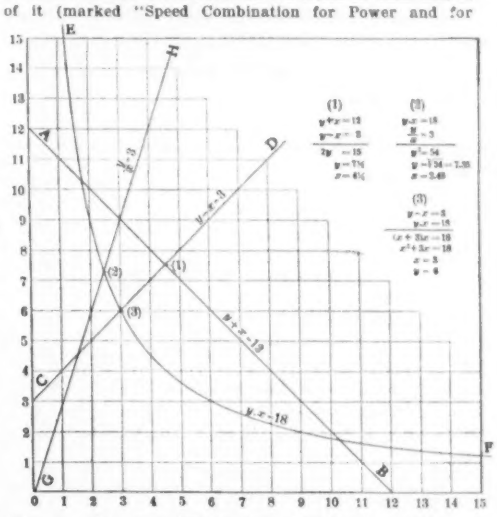


Fig. 1. Diagram Illustrating Graphical Solution of Problems.

Speed," respectively) are equivalent to the x scales on the rule in Fig. 2. The rest of the scales represent the various other variables that enter into the problem of determining the proper feed and speed combination to be used, fixed values being either directly given or assigned to these other variables, in any particular case under consideration.

The upper section of the rule embodies all the variables that enter into the question of available *cutting pressure* at the tool, while the lower section embodies all the variables that enter into the question of *cutting speed*; or, in other words, the upper section deals with the *pulling power* of the lathe, the lower section with the *cutting properties* of the tool; and our aim is primarily to utilize, in every case, both of these to the fullest extent possible.

The example for which the rule has been set in the illustration is: A ½-in. depth of cut to be taken with each of two tools on a material class 14 for hardness, and of 20 ins. diameter, and the tools to last 1 hour and 45 minutes under a good stream of water.

The steps taken in setting the rule were: 1. The first scale in the upper or "Power" section of the rule, from above, was first set so that 2 in the scale marked "Number of Tools" became coincident with ½-in. in the fixed scale marked "Depth of Cut for Power." 2. The second slide in this section of the rule was so set that 20 ins. in the scale marked "Diameter of Work for Power" became coincident with 14 in the scale marked "Class Number for Power." 3. The first slide from below, in the lower or "Speed" section of the rule was so set that the arrow marked "With Water" became coincident with 1 hour 45 minutes in the fixed scale marked "Life of Tool." 4. The arrow on the lower side of the second slide in this section of the rule was set to coincide with ½-in. in the scale marked "Depth of Cut for Cutting Speed." 5. The third and last slide in this section was so set that 20 ins. in the scale marked "Diameter of Work for Cutting Speed" became coincident with 14 in the scale marked "Class Number for Cutting Speed."

Let us now separately direct our attention to each of the two sections of the rule.

In the "Power" section we find that all the speed combinations marked B (back gear out), are entirely beyond the scale of feeds, which means that the estimated effective

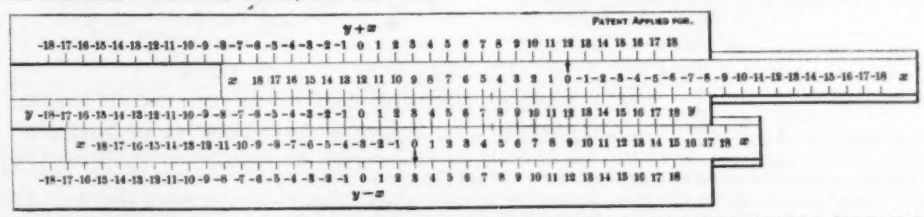


FIG. 2. SLIDE RULE FOR SOLVING PROBLEM OF FINDING TWO NUMBERS WHOSE SUM AND DIFFERENCE IS KNOWN.

*The main frame of the rule is used for a number of lathes, and is arranged to receive interchangeable specific scales for any lathe wanted, as may be seen in the illustration.

pull of the cone belt reduced down to the diameter of the work, does not represent enough available cutting pressure at each of the tools to enable a depth of cut of ½-in. to be taken with even the finest feed of the lathe. Turning, however, to the speed combinations marked A (back gear in), we find that with the least powerful of them (5—A—F) the e feed, which amounts to $^5/_{100}$-in. = 0.039-in., may be taken; while the f feed, which amounts to $^1/_{30}$-in. = 0.05-in., is a little too much for it, though it is within the power of the next combination (5—A—S), and so on until we finally find that the most powerful combination (1—A—S) is nearly capable of pulling the i feed, which amounts to $^1/_{10}$-in. = 0.1-in.

In the "Speed" section of the rule we likewise find that all the B combinations lie beyond the scale of feeds, while we find that the combination 5—A—F (which corresponds to a spindle speed of 11.47 revolutions per minute), can be used in connection with the finest feed (a) only, if we are to live up to the requirements set for the life of the tool; while the next combination (4—A—F) will allow of the a feed being taken, the combination 3—A—F of the f feed, and so on until we finally find that the combinations 3—A—S is but a little too fast for the coarsest (o) feed, and that both of the slowest combinations (1—A—S and 2—A—S) would permit of even coarser feeds being taken, so far as only the lasting qualities of the tools are concerned.

We thus see that there is a vast difference between what the "Power" section of the rule gives as possible combinations of feeds and speeds for the utilization of the full power of the lathe, and what the "Speed" sections of the rule gives for such combinations for the utilization of the tools up to the full limit set. However, by again running down the scale of feeds we find that, in both sections of the rule, the i feed ($^1/_{10}$-in. = 0.1-in.), is but a trifle too coarse for the combination 1—A—F, while the h feed ($^3/_{64}$-in. = 0.078-in.) is somewhat too fine in connection with this speed combination 1—A—F, both for the full utilization of the pulling power of the belt on the one hand, and for the full utilization of the cutting efficiency of the tools on the other hand.

In this case, accordingly, the rule does not leave a shadow of doubt as to which speed combination should be used, while it leaves us to choose between two feeds, the finer of which does not allow us to work up to the full limit of either the belt or the tools, and the coarser of which will both overload the belt a trifle and ruin the tools a trifle sooner than we first intended to have them give out.

The final choice becomes a question of judgment on the part of the "Slide Rule and Instruction Card Man," and will depend upon how sure he is of having assigned the correct "Class Number" to the material or not; and this latter consideration opens up a number of questions in regard to the practical utilization of the rule, which for the lack of time cannot be taken up in the body of this paper, but which will be fully answered by the writer in any discussion on the subject that may arise.

Having decided upon the speed and feed to use, the Instruction Card Man now turns to the "Time" slide rule illustrated in Fig. 4, and by means of this determines the time it will take the tools to traverse the work to the extent wanted, and making a fair allowance for the additional time consumed in setting the tools and calipering the work, he puts this down on the instruction card as the time the operation should take.

For finishing work the pulling power cuts no figure, so that this resolves itself into a question of feed and speed only; and for the selection of the speed combination that on any particular lathe will give the nearest to a desired cutting speed, the "Speed" slide rule illustrated in Fig. 5 is used.

It will readily be realized that a great deal of preliminary work has to be done before a lathe or other machine tool can be successfully put on a slide rule of the kind described above. The feeds and speeds and pulling power must be studied and tabulated for handy reference, and the driving belts must not be allowed to fall below a certain tension, and must, in every way, be kept in first-class condition.

In some cases it also becomes necessary to limit the work to be done, not by the pull that the belts can be counted on to exert, but by the strength of the gears, and in order to quickly figure this matter over the writer also designed the "Gear" slide rule illustrated in Fig. 6, which is an incorporation of the formulæ established several years ago by Mr. Wilfred Lewis.

For the pulling power of a belt at different speeds, the writer has established new formulæ, which take account of the increasing sum of the tensions in the two sides of a belt with increasing effective pull, and which at the same time are based on the tensions recommended by Mr. Taylor in his paper, entitled "Notes on Belting," which was presented at the meeting of the society in December, 1893.*

These formulæ have also been incorporated on a slide rule, but as the writer hopes at some future time to prepare a separate paper on this subject, he will not go into this matter any further at the present time.

Having thus given an outline of the use of the slide rule system of predetermining the feeds and speeds, etc., at which a machine tool ought to be run to do a piece of work in the shortest possible time, the writer, who has made this matter an almost exclusive study during the last four years, and who is at present engaged in introducing the "Instruction Card and Functional Foremanship System" into two well-known Philadelphia machine shops, which do a great variety of work in both steel and cast-iron, will merely add that, in view of the results he has already obtained, in connection with the results obtained at Bethlehem, the usual way of running a machine shop appears little less than absurd.

Thus already during the first three weeks of the application of the slide rules to two lathes, the one a 27-in., the other a 24-in., in the larger of these shops, the output of these was increased to such an extent that they quite unexpectedly ran out of work on two different occasions, the consequence being that the superintendent, who had previously worried a good deal about how to get the great amount of work on hand for these lathes out of the way, suddenly found himself confronted with a real difficulty in keeping them supplied with work. But while the truth of this statement may appear quite incredible to a great many persons, to the writer himself, familiar and impressed as he has become with the great intricacy involved in the problem of determining the most economical way of running a machine tool, the application of a rigid mathematical solution to this problem as against the leaving it to the so-called practical judgment and experience of the operator, cannot otherwise result than in the exposure of the perfect folly of the latter method.

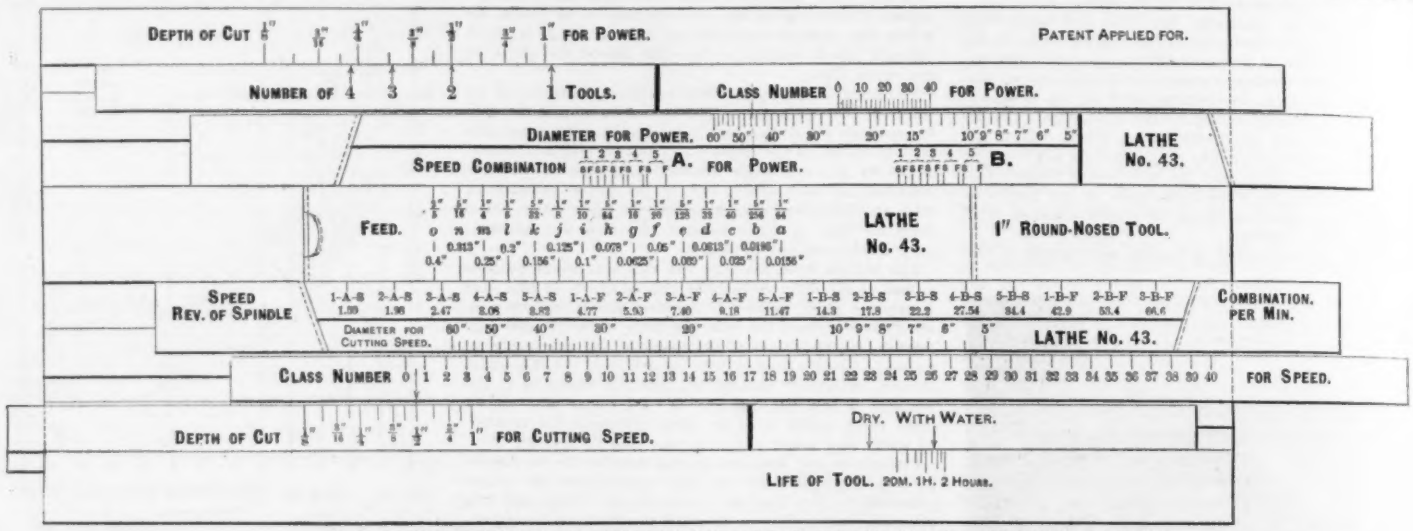


FIG. 3. SLIDE RULE FOR DETERMINING LATHE SETTINGS FOR MAXIMUM OUTPUT.

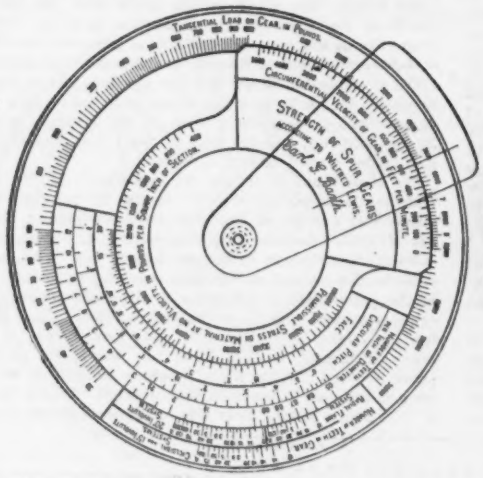


Fig. 4.

Fig. 5.

Fig. 6.

FIGS. 4, 5 AND 6. CIRCULAR SLIDE RULES FOR USE OF INSTRUCTION CARD FOREMAN.

*Engineering News, Dec. 7 and 14, 1893.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

A record-breaking attendance marked the forty-eighth annual meeting of the American Society of Mechanical Engineers, held in New York City last week; fully eight hundred names of members and guests were entered on the register of attendance. The meeting was distinguished primarily by the attendance, for the professional proceedings were not of exceptional quality.

The meeting extended over the four days from Tuesday, Dec. 1, to Friday, Dec. 4. On the evening of Dec. 1, President J. M. Dodge (Philadelphia, Pa.), formally opened the meeting with the annual presidential address; his discussion of "The Money Value of Technical Training" proved very interesting. The address is reprinted on another page of this issue. The second, third and fourth sessions were held on the morning of Wednesday, Thursday and Friday, respectively. Because of the restricted accommodations at the society's house, the meetings of Wednesday and Thursday were held elsewhere: the former at Mendelssohn Hall, 113 West 40th St., New York, and the other at Stevens Institute of Technology, Hoboken, N. J.

Social entertainment was well provided for, as is customary with the society. On Wednesday afternoon the three monster electric power stations of the New York Edison Co., the Manhattan Railway Co., and the Metropolitan Street Railway Co., respectively, were open for inspection by the members, and full advantage was taken of the opportunity. On the succeeding afternoon, immediately after the professional session at Stevens Institute, Mr. H. Goldschmidt, of Essen, Germany, delivered a lecture on "Alumino-Thermics," which was fully illustrated by demonstrations of welding rails, pipes, etc., producing nickel, and other applications of "thermite" working. On the evening of the same day occurred the society's annual reception and ball, at Sherry's, New York city. The afternoon of the last day of the meeting, Friday, was utilized for an excursion to the works of the De Laval Steam Turbine Co., at Trenton, N. J., on invitation of that company.

Business Proceedings.

The report of the council of the society covered quite in detail the administration of the house and library and the finances, and in addition reported the principal official acts of the council as the society's agent. Concerning the finances, we may note that the year's receipts and expenses were in the neighborhood of $37,000 each; however, the expenses exceeded the income by over $1,100, or about 3%, so that the year shows a net deficit of nearly $0.50 per paying member. Among the council's recent official acts we may note: the selection of Chicago as the place of the next meeting (Spring, 1904), and the following:

Mr. C. J. H. Woodbury of Boston had been asked to represent the society at a conference for the revision of the National Standard Electrical Rules, and as such representative has furnished a report of the action of the conference.

The council has expressed the interest of the society in co-operating with the American Reception Committee of the Iron and Steel Institute of Great Britain in their undertaking to provide for a meeting in 1904, of that organization, in the United States.

The council has acted favorably upon a request that a provisional committee should be created to consider and report upon a tonnage basis for expressing the effectiveness of refrigerating machinery, which could be made generally acceptable as a standard. Such committee is to consist of five persons, appointed by the President.

In connection with this report Mr. C. W. Hunt (New York) gave an outline of the history of the Union Engineering Building project, to date, which history our readers are sufficiently familiar with.

Certain amendments to the constitution offered at a previous meeting of the society have within the past few months been submitted to letter-ballot. The count of this vote, as announced at the meeting, was 437 in favor to 5 against; the amendments are therefore declared adopted.

The election of officers, also carried on by letter-ballot, resulted in the ratification of the nominees selected by the nominating committee. The new officers are the following: President, Mr. Ambrose Swasey (Cleveland, O.); Vice-Presidents, Prof. D. S. Jacobus (Hoboken, N. J.), Mr. M. L. Holman (St. Louis, Mo.), and Mr. W. J. Keep (Detroit, Mich.); Treasurer, Mr. W. H. Wiley (New York, N. Y.); Managers, Prof. E. H. Lockwood (New Haven, Conn.), Mr. J. W. Lieb (New York, N. Y.), and Mr. A. M. Mattice (Pittsburg, Pa.).

Within a year and a half from now will occur the twenty-fifth anniversary of the formation of the American Society of Mechanical Engineers. A suggestion was made by Mr. H. H. Suplee (New York, N. Y.) that this occasion be taken to prepare a history of the society, and in connection with it an account of the many interesting antiquarian objects which are among the society's possessions, but which are now unknown and unnoticed. In accordance with this suggestion, on vote of the society to have the plan carried out by a committee, President Dodge appointed Messrs. H. H. Suplee, C. W. Hunt and J. E. Sweet to prepare the history.

The society's historical relics, just referred to, were added to in an unexpected manner, as was announced in the course of the meeting, by the donation of a bust of John Ericcson. The bust, donated by Mr. C. B. Mapes, was made during the lifetime of the great engineer, and was considered very satisfactory both by him and by his friends.

At the close of the meeting, Mr. G. I. Rockwood (Worcester, Mass.) brought up the matter of the subscriptions raised every year among the New York members to cover the expense of the annual meeting. He expressed the opinion that this virtual tax on the New York members was unfair, and that opportunity should be given the "outside" members to contribute to this expense. A difference of opinion on this matter immediately developed. Prof. W. S. M. Goss (Lafayette, Ind.) took Mr. Rockwood's position. Mr. S. Miller (New York, N. Y.) thought it only fair that the charge should fall on the New York members, as they need pay no railway fare to attend these meetings: however, he suggested that the expense should be met by increased dues for the local members rather than by subscription, in which he was supported by Mr. F. A. Halsey (New York). The objection was urged that the expense in question is too considerable to be met by increased dues for New York members, and finally, on motion of Mr. C. W. Hunt (New York, N. Y.), the matter was referred to the executive committee of the council for consideration.

Professional Proceedings.

The professional work of the meeting comprised the presentation and discussion of some fifteen papers, and the consideration of a committee report on Steel Specifications. This latter came up for discussion early in the meeting, and we therefore note it in advance of the papers.

SPECIFICATIONS FOR STEEL.

A year ago a committee of the American Society for Testing Materials drew up a set of specifications for certain steel materials, namely: boiler plate, rivet steel, steel castings and steel forgings. In order to secure fullest criticism before approving these specifications, that society asked the American Society of Mechanical Engineers to discuss them. In accordance with this request a committee was appointed at the last meeting of the society to consider the specifications, and after correspondence with the individual members of the society the committee prepared certain recommendations for changes. These recommendations, and the specifications as revised accordingly, were submitted by the committee at the present meeting.

Criticism of the completed specifications was not wanting. Mr. G. C. Henning (New York, N. Y.) attacked the recommended definition of elastic limit as being erroneous and impracticable, and even more strongly criticised the proposal that the determination of the yield point for "ordinary grades" be omitted. This last recommendation was also criticised by many others, among them Prof. G. Lanza (Boston, Mass.), Prof. R. C. Carpenter (Ithaca, N. Y.), and others. Several other features of the recommended specifications were also criticised. On motion of Mr. J. Christie (Pencoyd, Pa.) the entire specifications were without further action referred back to the committee of the American Society for Testing Materials.

WAGE SYSTEMS AND SHOP MANAGEMENT.

For several years past the society has given an increasing amount of time, and certainly no diminished interest, to the discussion of questions relating to methods of paying workmen and shop management. Three papers in this field came before the present meeting. Mr. Frank Richards (New York, N. Y.), under the title of "Is Anything the Matter with Piece-Work?" made an argument against the variable-rate, bonus, and premium wage systems, and upheld the piece-work system as being a fairer way of treating the workman. Mr. H. L. Gantt (Schenectady, N. Y.) very briefly discussed two arguments made against the bonus plan, the title of his paper being "Modifying Systems of Management." The third paper was "Slide-Rules for the Machine Shop as Part of the Taylor System of Management," by Mr. C. G. Barth (Philadelphia, Pa.), in which slide-rules for computing the feeds, speeds, etc., of machine tools were described.

The paper of Mr. Richards considered systems of payment from the point of view of the incentive they offer to increased output. Paying by the day offers no incentive to increased output, and on a diagram whose ordinates are wage per day while the abscissas are work done per day, the day-work system is a horizontal line. The piece-work system is represented as a rising line of uniform slope. The Halsey premium system is a broken line, the part for output above the minimum being inclined like the piece-work line. The Rowan system is also represented by a broken line, the upper part of which is a curve flattening in slope as the output per day increases, thus representing a decreasing incentive. It was urged that any system which pays less per piece for the greater number of pieces offers a decreasing incentive to increased output, and, moreover, is unfair to the workman.

In connection with his paper itself, Mr. Richards presented virtually a second paper, which constituted a strong protest against the tendency to treat the shop worker partly as a child and partly as a machine. His position was that the only progressive and true way was to consider the workman as a human being strongly interested in doing his work well and advancing himself to increased efficiency. The divided foremanship, the decreasing rate wage scale, and the detail direction of workmen all were condemned as being in conflict with this principle and unfair to the workman.

Mr. Gantt's paper considered two objections which had been presented to the author against the "instruction and bonus" system. The first objection was that the attempt to introduce the system would in many shops call forth a strike. Mr. Gantt's answer is that the introduction may be made obnoxious and it may not; in the latter case, with time and patience, no opposition from the workmen need be expected. The second objection was that if maximum output can be secured at all, then the workmen should not receive extra pay for it; the obvious answer was that without special inducement it cannot be secured.

The paper of Mr. Barth, on "Slide-Rules for the Machine Shop," is printed elsewhere in this issue. This paper was presented at the end of a long session, when no time was available for discussion. The only public discussion which it received, therefore, was a written communication which was merely announced.

The other two papers were discussed with considerable interest. Mr. H. Emerson (London, England) was the first to attack the piece-work argument of Mr. Richards. He claimed that the variable-rate wage systems did offer a sufficient incentive for increased output, and showed diagrams of earnings for unit time in support of this. As to the question of fairness involved in paying the workman less per piece, as his rate of working increases, he claimed it was only fair that the employer and the workman should divide the profit secured by decreasing the time of work for a given piece. This was answered by the statement that even in piece-working the employer gains, through reduced fixed charges, as the output increases. Mr. H. L. Gantt (Schenectady, N. Y.) referred to the West Albany shops of the N. Y. C. & H. R. R. R., which had been cited as an instance of how efficient work may be done without any new system. He said that the rapid rate of tire turning at these shops was quite probably secured by copying the "new system" methods put into practice at the General Electric shops in Schenectady. Moreover, it has been planned to

introduce the new method of management in the West Albany shops themselves, and the plan was only deferred for extraneous reasons. Mr. Oberlin Smith (Bridgeton, N. J.) pointed out the distinction between jobbing shops, manufacturing shops, and shops of miscellaneous work. In the first probably nothing but day-working can ever be used. In the second, where repetitive work prevails, the special systems of payment have their field. The third class constitutes probably 80% of all machine shops, and the important question is: can the "new systems" be applied here? Where only one or two, at most ten, duplicate pieces are made at once, is it possible or practicable to analyze the work for minimum time, to determine the allowable time of working, and pay on this basis? Mr. F. W. Taylor (Philadelphia, Pa.) replied to this by saying that at the Bethlehem Steel Co., Bethlehem, Pa., where most of the work is miscellaneous (in small lots), the instruction card and premium system has been used exclusively for several years, with full success. This shop, however, works largely on heavy work. On the general question of method of payment, Mr. Taylor gave the opinion that it is a matter of secondary importance; all of the methods of payment have each its separate field and several or all may exist side by side in the same shop. The fundamentally important matter is management: it is essential to have the means of finding out, and to find out, what is a good day's work; that is, what can fairly be done by the workman, and further, to see that this amount is done or approximated. Mr. N. Du Brul (Cincinnati, O.), Mr. S. Balkwill (Cleveland, O.), and others, also spoke on the subject.

The discussion, on the whole, was favorable to the "new methods," Mr. Richards and Mr. Smith being almost the sole supporters of the conservative side.

Following, a paper by Mr. J. E. Sweet (Syracuse, N. Y.), entitled "What Are the New Machine Tools to Be?" was taken up for discussion. The paper was reprinted in our last issue and need not be further noted here. It was discussed by Mr. J. D. Riggs (Pittsburg, Pa.), Mr. H. P. Fairfield (Worcester, Mass.), and Mr. Oberlin Smith (Bridgeton, N. J.). It was conceded that machine tools are generally too light, especially so lathes and planers. In the former a heavier headstock is necessary in nearly all cases, and the bed and carriage also need more weight. Motors may be incorporated in the design of the machine itself, and in tools like radial drills much driving mechanism may be saved by mounting the motor near the work, as on the radial arm. Planers will be much less used in the future, according to Mr. Smith, because their reciprocating motion, with the work moving, is very impractical, since it limits the speed apart from consideration of the tool. The interesting information was elicited from Mr. F. W. Taylor, on question of Mr. Smith, that the new high-speed tool steels are not stronger than ordinary carbon tool steel, in fact not as strong; the tungsten or molybdenum weaken the steel and reduce its ability to stand up to heavy cuts.

A paper by Prof. W. B. Gregory (New Orleans, La.), on "The Pitot Tube," was read in abstract by the secretary, but was not discussed. The paper gives a recapitulation of some of the important experimental work done with the Pitot tube, and then recounts the application of the device to measuring velocities in the discharge pipes of suction dredges on the Mississippi River. The tubes used there were so selected, as the result of experimentation, that the velocity could be computed directly from the formula

$$v^2 = 2\ g\ h,$$

without any corrective coefficient.

"A Method for Determining Rates and Prices for Electric Power" is the title of a paper presented by Mr. F. B. Perry (Allston, Mass.). A common provision in electric power contracts is that the power shall be paid for at a given rate per unit up to a certain number of kilowatts average used, a given lower rate per unit if the power used exceeds this number of kilowatts, a still lower rate if the power used exceeds a further point, etc. This sliding scale system (which, we may note, is also common in the sale of water) leads to inconsistencies in the prices actually paid; in certain cases money may be saved by using a larger amount of power than necessary. The author suggests that instead of this method of charging, curve sheets or schedules of rates be used in electric power contracts, so as to give at sight, for any quantity of power used, the proper rate, the rates being computed in such a manner as to give a constantly increasing total price for increasing power consumption.

It was pointed out in discussion that simpler methods of charging are giving satisfactory results. With the sliding scale rate, it is usual to provide that the price paid shall in no case be higher than if the next lower rate had been secured by using a larger amount of power. (This provision is also used in water contracts.) A still better method is the block method: a fixed rate, A, per unit for the first 1,000 KW. used, a lower rate, B, per unit for power used in excess of 1,000 KW., up to a total of 2,000 KW., a still lower rate, C, for power used in excess of 2,000 KW., etc.

Prof. D. S. Jacobus (Hoboken, N. J.) presented a paper entitled "Tests of a Compound Engine Using Superheated Steam," which reported some excellent economy results. We expect to reprint this paper in our next issue. We may mention here that the superheated steam was furnished by an independently-fired superheater, and the discussion of the paper first turned on this point. Mr. G. I. Rockwood (Worcester, Mass.) stated that in a steam turbine power station which he had recently visited he had found the fire-door of the superheater blocked open permanently in order to keep down the fire. The object of this was to avoid superheating too high and also to avoid burning out the superheater; the former object alone could be attained by by-passing some of the steam around the superheater, but this would rapidly burn out the superheater tubes. He has recently been able to use a special artifice for this purpose: in a plant which furnishes steam for a dyehouse and also a much smaller amount to an engine, the steam for the engine being passed through a superheater. When it is desired to reduce the superheat, or when the engine is stopped, some of the dyehouse steam is turned through the superheater and the temperature of the latter is thereby kept down to the desired point. Mr. R. H. Rice (Providence, R. I.), of the firm that built the engine tested by Professor Jacobus, mentioned some of the special details of the design. The poppet-valve seats are surrounded by live steam, to avoid trouble from difference of expansion of valve and seat. The stuffing-boxes are on long necks, to remove them farther from the heat of the steam. The valve-gear is of the Corliss type, but with independent linkage to give full closing and avoid slamming. Regarding the Newport, R. I., superheater referred to by Mr. Rockwood, Mr. Rice stated that it was designed for a very much larger load than has yet been put on it, which is the reason the fire-door is kept open.

The cylinder ratio of the engine tested by Professor Jacobus was the subject of some discussion. The ratio of high pressure to low pressure cylinder volume is about 3 to 1, which ratio was copied from European practice in superheated steam engines. Professor Jacobus stated that it might be found that lower cylinder ratios need to be used with superheated than with saturated steam, but that there is yet no definite knowledge on this matter.

A paper entitled "The Pressure-Temperature Curve of Sulphurous Anhydride, SO_2," by Prof. E. F. Miller (Newton Center, Mass.), was read in abstract by the secretary. Experiments to determine the relation of pressure to temperature of saturated SO_2 vapor are described in this paper, and a table of resulting values is given. We reproduce this table herewith.

Pressures and Temperatures of Saturated Vapor, of Sulphurous Anhydride, (SO_2). From Experiments of E. F. Miller and D. D. Mohler.

Temp. °F.	Pressure Lbs. Absolute.	Temp. °F.	Pressure Lbs. Absolute.	Temp. °F.	Pressure Lbs. Absolute.	Temp. °F.	Pressure Lbs. Absolute.	Temp. °F.	Pressure Lbs. Absolute.	Temp. °F.	Pressure Lbs. Absolute.
−40	3.1	8	11.9	46	30.7	89	70.8	133	139.9	176	257.0
−39	3.2	4	11.5	47	31.4	90	71.6	132	141.9	176	260.5
−38	3.3	5	11.8	48	33.1	91	72.9	134	143.9	177	264.0
−37	3.4	6	12.1	49	33.8	92	74.1	135	146.0	178	267.6
−36	3.6	7	12.4	50	33.5	93	75.4	136	148.2	179	271.2
−35	3.7	8	12.7	51	34.2	94	76.7	137	150.5	180	274.9
−34	3.8	9	13.1	52	34.9	95	78.0	138	152.8	181	278.6
−33	4.0	10	13.4	53	35.6	96	79.3	139	155.2	182	282.4
−32	4.1	11	13.7	54	36.4	97	80.7	140	157.6	183	286.3
−31	4.2	12	14.0	55	37.1	98	82.1	141	159.9	184	290.2
−30	4.3	13	14.4	56	37.9	99	83.5	142	162.3	185	294.2
−29	4.5	14	14.8	57	38.7	100	84.9	143	164.7	186	298.2
−28	4.7	15	15.2	58	39.4	101	86.3	144	167.1	187	302.2
−27	4.9	16	15.6	59	40.2	102	87.7	145	169.5	188	306.2
−26	5.0	17	16.0	60	41.0	103	89.1	146	171.9	189	310.2
−25	5.1	18	16.4	61	41.8	104	90.6	147	174.4	190	314.3
−24	5.2	19	16.8	62	42.6	105	92.1	148	176.9	191	318.4
−23	5.4	20	17.2	63	43.4	106	93.6	149	179.5	192	322.6
−22	5.5	21	17.6	64	44.3	107	95.1	150	182.1	193	326.8
−21	5.7	22	18.0	65	45.2	108	96.7	151	184.8	194	331.1
−20	5.9	23	18.4	66	46.1	109	98.3	153	187.4	195	335.4
−19	6.0	24	18.9	67	47.0	110	99.9	153	190.0	196	339.8
−18	6.1	25	19.3	68	47.9	111	101.5	154	192.7	197	344.2
−17	6.3	26	19.7	69	48.8	112	103.1	155	195.4	198	348.7
−16	6.5	27	20.1	70	49.7	113	104.7	156	198.2	199	353.2
−15	6.7	28	20.6	71	50.6	114	106.3	157	201.0	200	357.7
−14	6.9	29	21.0	72	51.6	115	108.0	158	203.8	201	362.3
−13	7.1	30	21.5	73	52.6	116	109.7	159	206.6	202	367.0
−12	7.3	31	22.0	74	53.6	117	111.4	160	209.5	203	371.8
−11	7.5	32	22.5	75	54.6	118	113.2	161	212.4	204	376.7
−10	7.8	33	23.1	76	55.6	119	115.0	162	215.3	205	381.6
−9	8.0	34	23.6	77	56.6	120	116.8	163	218.3	206	386.6
−8	8.3	35	24.2	78	57.7	121	118.6	164	221.4	207	391.7
−7	8.5	36	24.7	79	58.8	122	120.5	165	224.5	208	396.7
−6	8.7	37	25.3	80	59.9	123	122.4	166	227.6	209	401.8
−5	9.0	38	25.9	81	61.0	124	124.3	167	230.7	210	407.0
−4	9.3	39	26.5	82	62.1	125	126.2	168	233.9	211	412.5
−3	9.5	40	27.1	84	63.2	126	128.1	169	237.1	212	418.0
−2	9.7	41	27.7	84	64.3	127	130.0	170	240.3		
−1	10.0	42	28.3	85	65.5	128	131.9	171	243.6		
0	10.3	43	28.8	86	66.7	129	133.9	172	246.9		
1	10.6	44	29.4	87	67.9	130	135.9	173	250.2		
2	10.9	45	30.1	88	69.1	131	137.9	174	253.6		

In a communication from Mr. Walton (Ithaca, N. Y.) the values given in the paper were compared with those deduced from Ramsay and Young's law; the values agree up to 157° F., above which point the temperatures given by the paper are lower than those given by the law.

A new form of engine with Corliss valves was described by Mr. B. T. Allen (Harrisburg, Pa.) in a paper on "Construction and Efficiency of a Fleming Four-Valve Engine Directly Connected to a 400-KW. Generator." An abstract of this paper was given in our last issue. The paper fails to describe the actual design of the positive valve gear, and the author promised to add a description of the gear before final publication in the "Transactions." Discussing the paper, Prof. R. C. Carpenter (Ithaca, N. Y.) showed a diagram of the total steam consumption for varying load, as drawn from the figures given in the paper, and pointed out that this gave a straight rising line, in accordance with what is known as Willans' law, a law which holds generally for engines with throttling governor. Shaft governors usually give a curve convex to the X-axis. He attributed the low steam consumption shown by this engine at light load to the fact that lower steam pressure was used in the light load test than at higher loads; had this not been the case the curve of total steam used would probably have been convex to the X-axis as for all other engines of either the Corliss or the automatic type. In answer to a question by Mr. C. H. Wheeler (Short Hills, N. J.), the author stated that the condenser air pump was independently driven, but the steam used by it was not allowed for in the results. Mr. G. I. Rockwood (Worcester, Mass.) questioned the author's figure of 4⅞% for the clearance of the low pressure cylinder and stated that he himself had never been able to reduce the clearance below 6% in similar engines. He expressed doubt whether the effort to secure higher speed of revolution with shorter stroke was a move in the right direction.

Mr. F. A. Scheffler (Glen Ridge, N. J.), in a paper entitled "Suggestions for Shop Construction," recommended a radial arrangement of shops, centering in an administration building. A railway track encircling the buildings, and another one on the inner circle, surrounding the administration building, would offer convenient means of transportation between the individual (radial) shop buildings. The paper elicited no discussion.

GAS ENGINES.

Only one gas engine paper came before the meeting: Mr. C. H. Morgan (Worcester, Mass.) described "A Compact Gas Engine, Beam Type." The design described is now being constructed. Its essential features are placing the cylinders (two) vertical, using a special valve gear, and making the crank connection through an intermediate bell crank, the piston rods (trunk pistons are used) being connected to the ends of the opposite straight arms, while the connecting rod is pinned to the third arm of the lever. The object of the construction is to minimize the lateral pressure on

the cylinder walls, which lateral pressure is by this arrangement transferred to the pin on which the bell crank rocks. The valve gear is operated by rods attached to the bell crank, and actuates the valve through a trigger arrangement having a release governed like that of a Corliss valve. As designed, the engine employs the two-stroke cycle; separate air and gas pumps prepare the charges and provide air for scavenging. The exhaust is through ports uncovered by the piston near the bottom of its stroke, and the scavenging air is admitted through the inlet valve.

Prof. S. A. Reeve (Worcester, Mass.) showed diagrams of the pressures on the principal pins of the engine at various points of the stroke, as computed. He calculated that the engine could work satisfactorily up to 1,000 ft. per minute piston speed, though the design is for a normal speed of 810 ft. per minute. Mr. B. H. Thwaite (London, England), who was present at the meeting as a guest, made some interesting remarks on the recent development of gas engines; the dust problem, he declared, has been fully solved, and he has himself invented a washer for freeing blast furnace or producer gas of dust, which has been adopted by the John Cockerill Co. He expressed the hope that American engineers would make full utilization of blast furnace gas engines for power purposes; blast furnace gas he considers an almost ideal fuel, for although not as rich as producer gas, requiring only a volume of air equal to itself, it is made equally suitable for combustion in the gas engine by higher compression; and then in fact excels producer gas because its very leanness makes it less subject to premature ignition. Mr. E. A. Uehling (New York, N. Y.) quoted some calculations he had made as to the power available from blast furnaces. He finds that the gas produced will yield about 800 HP. for each ton of iron produced per hour; this figure of 800 HP. assumes the gas engine to have a thermal efficiency of 25%, which is often exceeded. For the amount of compression required in gas engines a convenient rule was given by Mr. H. H. Suplee (New York, N. Y.): the degree of compression should be in inverse proportion to the richness of the gas, this rule was confirmed by Mr. Thwaite.

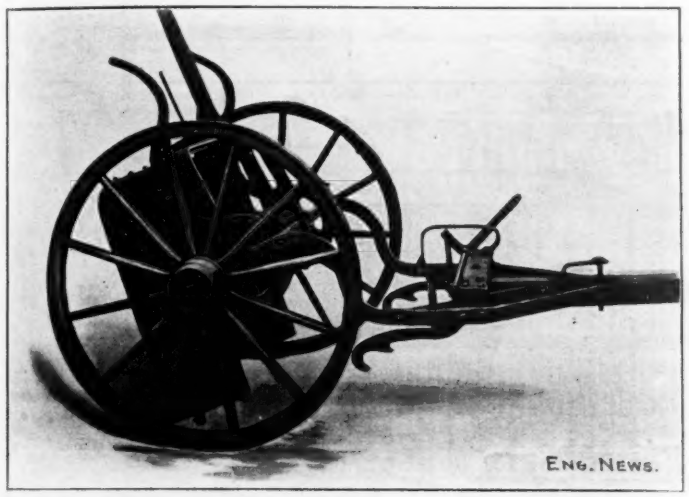


FIG. 2. VIEW OF STUBBS SCRAPER WITH PAN DUMPED.

STANDARDS FOR REFRIGERATING MACHINERY.

A paper by Mr. J. C. Bertsch (Atlanta, Ga.) entitled "A Standard Unit of Refrigeration," made an appeal for action by the society to formulate standards for rating refrigerating machinery. It further contained certain suggestions for such standards. These suggestions are of two kinds, as pointed out by Prof. D. S. Jacobus (Hoboken, N. J.): first, a suggestion for a standard unit of refrigeration, and, second, suggestions for standard speeds, capacities, condensing temperatures, etc., to be used in rating refrigerating machinery. The proposed unit is:

> One ton of refrigeration is the latent heat absorbed or set free by melting or making one ton of ice of 32° F. to or from water of 32° F.

This unit equals 284,000 B. T. U. It seems to be generally conceded that this is a satisfactory unit. The second class of suggestions made by the author brought to light some differences of opinion, and it is this part of the standardization question which will give trouble, since whatever conditions are adopted as standard it will be unfair to those builders of refrigerating machinery who having adopted other standard conditions. As the society has already appointed a committee to consider the subject of such standards, as noted at the beginning of this report, we need not make further note of the discussion, except to remark that various criticisms or suggestions were made by Prof. S. A. Reeve (Worcester, Mass.), Mr. G. T. Voorhees (St. Louis, Mo.), Mr. Thos. Shipley (York, Pa.), and Mr. S. H. Bunnell (Lorain, O.).

Prof. W. F. M. Goss (Lafayette, Ind.) presented a paper on "A Series Distilling Apparatus of High Efficiency," which we shall reprint later. It was not discussed.

TESTING AIR TOOLS.

The Chicago, Burlington & Quincy R. R., through its testing department, has arranged a testing plant for making tests of the working of air tools, both rotary (motors for drills, etc.) and reciprocating (hammers). This plant was described in a paper on "Apparatus and Methods for Testing Air Motors and Air Hammers," by Mr. M. H. Wickhorst (Aurora, Ill.), who had the matter in charge for the railway company. This paper is also reprinted on another page. Some specimen tables of results are given in the paper, representing a test of one air motor and one air hammer. According to these tables, a surprising difference of efficiency is shown between the motor and the hammer. Our calculation shows an average efficiency of between 45 and 50% for the motor, assuming the exhaust to be at atmospheric pressure; the hammer, however, on the same assumption, shows only about 0.55 to 0.60% efficiency, or little more than one one-hundredth of the efficiency of the motor. Most of the difference is no doubt due to the method used for testing the hammers; the hammer was arranged to strike against a known weight, and from the mass, amount of motion, and number of oscillations of this weight the power delivered to it was calculated. The loss in impact was not taken account of. A communicated discussion from Mr. F. G. Hobart (Beloit, Wis.) characterized this method of testing as useful only for comparison, and mentioned a different method embodied in a testing machine built by Fairbanks, Morse & Co., of Beloit, Wis. In this machine a pencil connected with the plunger of the air hammer registers its motion on a strip of paper, so that the velocity of the plunger can be calculated for every point of the stroke. Then the velocity at the moment of striking the blow enables one to calculate the energy imparted to the plunger, without the complication of having to allow for impact effect. Unfortunately, Mr. Hobart gave no results obtained with this machine.

The last paper of the meeting was "An Improvement in Valve Motion of Duplex Air Compressors," by Mr. S. H. Bunnell (Lorain, O.). The improvement described applies to duplex compressors in which the separate cut-off valve (Meyer valve) is used in the steam end and the air valves are mechanically operated. It consists in actuating the cut-off valve of one side of the engine and the air valve of the other side from the same eccentric, by means of rocker arms and a cross-shaft run through the frame from one side to the other. Means are provided on the valve rod for separate adjustment of the cut-off valve and the air valve. The paper was presented in abstract by its author and was not further discussed.

The ceremony of presenting the new president, performed at the second session of the meeting, was notable in that the introduction of President Swasey was delegated to Past-President John E. Sweet (Syracuse, N. Y.), who is one of the men to whom the American Society of Mechanical Engineers owes its birth. The new president recalled this fact in his response, and related how Mr. Sweet twenty-three years ago told him of the proposed new society, and invited him to join it. He referred with pleasure to the great growth and success of the society in the years since then.

A NEW WHEELED SCRAPER.

The wheeled scraper is one of the most extensively used appliances for the handling of earth, and we illustrate herewith an improved design in which the operations are said to be greatly facilitated. It will be noticed that in front of the pan are hangers, each formed with two hooks to engage lugs on the side of the pan. These hangers are operated by links from a cross shaft to which is fitted a lever handle.

In loading the scraper, the pan is dropped so that the lugs rest on the lower hooks of the hangers, and the pull is therefore taken in line with the cutting edge. When raised to the carrying position, the draft is transferred to a point above and behind the axle, and the mouth of the pan is supported by the lugs resting in the upper hooks of the hangers, so that it cannot tilt or dump its load.

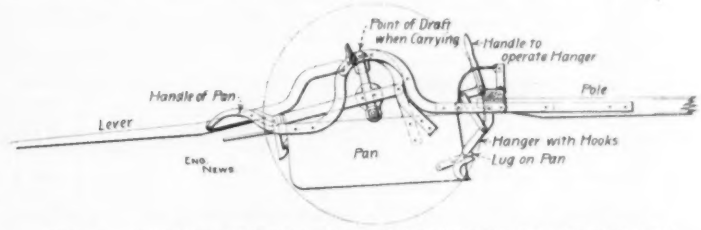


FIG. 1. SIDE ELEVATION OF STUBBS WHEELED SCRAPER (IN CARRYING POSITION).
Mechanical Mfg. Co., Chicago, Builders.

To dump the load, the hooks are released by the lever, allowing the mouth of the pan to drop to the ground. As the draft is from the top, as above noted, the team pulls the scraper over. In this way the driver can do his own dumping without assistance.

The scraper is said to be especially adapted to levee and embankment work, as it dumps easily in going uphill; and it can be used in gravel where others may fail to work, owing to a tendency to slide in dumping. It is claimed that the No. 3 scraper, which holds 16 cu. ft. of earth, can be operated by one man, saves time and labor in dumping, and also saves wear and tear on horses and equipment, for in dumping the pole has a steady forward movement, instead of a jerky motion that is likely to give the horses sore necks.

Fig. 1 shows the scraper in position for carrying the load, with the pan supported by the upper hook, and the draft of the team taken at a point above and behind the axle. Fig. 2 shows the scraper with the hooks disengaged and the pan partly dumped. This improved scraper was patented in September, 1900, by Mr. Jesse Stubbs, contractor, of Mount Pleasant, Ia. It is being manufactured by the Mechanical Mfg. Co., of Chicago, and we are indebted to the makers for plans and photographs.

THE U. S. STEEL FLOATING DRY-DOCK FOR CAVITE, PHILIPPINE ISLANDS.

By J. S. Shultz.*

With the acquirement by the United States of the Philippines and other Pacific island possessions, there came the necessity for maintaining a large Asiatic naval fleet, and this in turn required the establishment of a naval base in that vicinity, not alone for coaling and provisioning the vessels, but to afford means of repairing and overhauling

*U. S. Navy Yard, New York, N. Y.

them as well. The Congress of 1902-3, which was called upon to decide as to the location of this naval station, found that the problem was not at all easy of solution. The site selected had to be one that was best strategically, and at the same time so near the trade center of the islands that labor could be easily obtained. After careful consideration it was decided to build the station near Cavite, the exact position being left until the new lines of development in trade and population had been firmly established and a more detailed survey of the islands made.

Coincident with this discussion in Congress came the test in January, 1902, of the 12,000-ton steel floating dry-dock at Algiers, La.,—the first of its type to be used by the United States—and the Senate and House naval committees were so well pleased with the result of this test that recommendation was made to appropriate $1,200,000 for a similar structure as a nucleus for the new Cavite naval station. On July 1, 1902, this appropriation was authorized by Congress, for it was seen that vessels could be docked just as safely in a floating dry-dock as in one of the masonry type, and, in addition, that the former possessed the following advantages: (1) It could be built in three years, while a masonry dock would require at least six years for completion; (2) it would not require more than the estimated cost for building, while the initial cost of a masonry dock would be $2,500,000, and in case difficult foundations were met with the cost would be further increased; (3) the exact location would not have to be fixed, for the floating dock could be towed to a different place in case a more desirable one was found; (4) if at any future time the islands were disposed of, the floating dock could be brought back to the United States.

The specifications were prepared by Lieut. A. C. Cunningham, U. S. N., Corps of Civil Engineers, who superintended the construction of the Algiers dock; and, with the experience gained on this work, he was able to make these the most complete ever issued for a floating dock. In these specifications the actual design was left to the bidders, but the size was given in detail, and the general construction, and a lifting capacity of 16,000 gross tons, with 2 ft. free-board, were specified. The maximum allowable longitudinal and lateral deflections over the entire length of the dock were 1 in 2,000. Detailed descriptions of the method of self-docking were also given, as well as a complete list of the working equipment, together with the tests to which the structure would be subjected before final acceptance. It is also to be noted that the dock was to be an open-hearth steel structure of American manufacture. In short, Lieut. Cunningham strove to secure the best possible "military" dry-dock, for he recognized that the most serious defects in the docks of this class heretofore built were due to the fact that they were constructed with the commercial rather than the military purpose in view.

It was with no little interest, therefore, that the bids were opened on March 14, 1903, when it was found that this method of competitive design secured for the government from which to make selection no less than four distinct types of floating steel dry-docks, all of which fulfilled in every particular the specification requirements. Two of these were of the types that had been hitherto the standards of this class of naval architecture, viz., the Rennie dock, to which class belongs the first iron floating dock ever built, and the Clark & Standfield dock, which is the modern type used almost exclusively in Europe, and to which class also belongs the Algiers dock. It was of peculiar significance, however, that the two lowest bids were upon absolutely new designs, and that these designs were by American naval architects. One, for which $1,164,000 was asked, was of the bolted sectional type, patented recently by Lieut. Cunningham, and the other was an extremely novel structure designed by Mr. Dutton, Chief Engineer of the Maryland Steel Co. As the bid, $1,124,000, for this latter was the lowest, the above firm were awarded the contract on April 9, 1903, and the dock is to be completed by July 9, 1906.

The characteristic features of this structure are well shown in the accompanying illustrations (Figs. 1 and 2). It is seen that the dock will be a unit in itself, being equipped with eight steam capstans, two lifeboats, a machine shop, an electric plant, a distilling plant, a fire-protection system, sleeping and dining accommodations for the officers and crew in charge, etc.

Since the floating dock must be repaired as frequently as other floating steel craft, the self-docking feature is, next to the lifting power, the most important consideration; and it is in this capacity that the Cavite dock differs so radically from its predecessors. Formerly the self-docking was accomplished by building the docks in various sections, and thus by raising each part successively the entire structure could be overhauled; in this new type, however, the central portion, which is

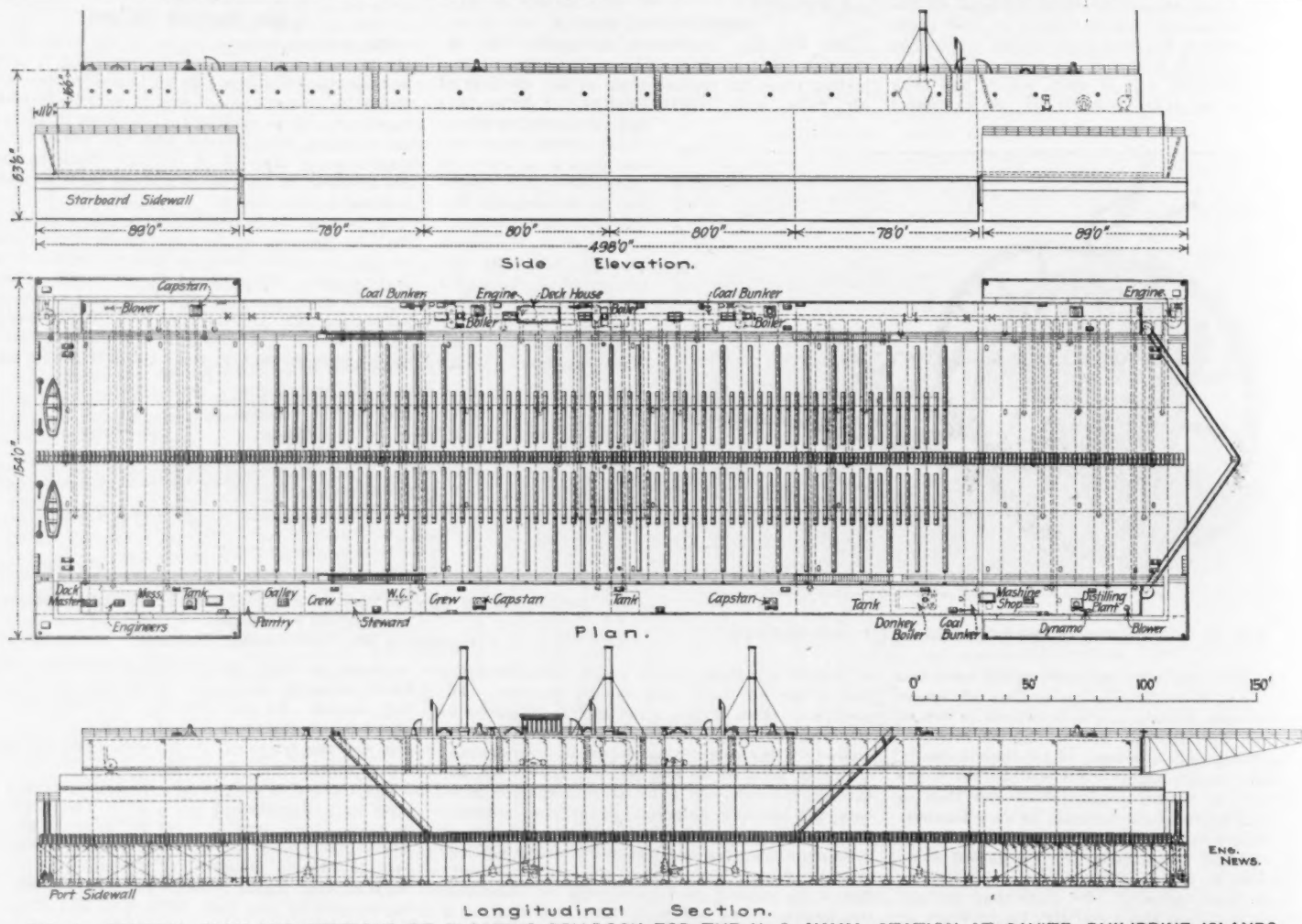


FIG. 1. GENERAL PLAN AND SECTIONS OF FLOATING DRY-DOCK FOR THE U. S. NAVAL STATION AT CAVITE, PHILIPPINE ISLANDS.
Maryland Steel Co., Sparrows Point, Md., Designers and Builders.

316 ft. long, comprises practically the whole of the dock, and it is an absolutely rigid riveted structure, the framing of the side walls, which are 63 ft. 6 ins. high, being a continuation of the framing of the bottom or central pontoon and extending to the full depth of this pontoon throughout its entire length, as is seen from the cross-section, Fig. 2. The ends of the walls of this central section project out over and are bolted to the end pontoons, which are made just large enough to provide the necessary buoyancy to lift the central section. Thus the only joints in the dock are horizontal ones, and are located as near the ends as possible, which is the least dangerous section, since the bending moment is far less than at the center or immediately under the turrets of the battleships.

The method of self-docking is clearly shown by the diagrams of Fig. 3, and is explained as follows in the description of the dock furnished by the Maryland Steel Co. with their plans:

When self-docking the dock, the water is first pumped out as low as practical with the main pumps, and water

is then freely admitted to all compartments on the starboard side outside of the starboard immediate bulkhead in the center pontoon only until the dock is heeled over sufficiently to bring the main drainage pipe on the port side well above water. The inner valves on the main drain will be closed, and the drain pipe connections between the pontoons are then disconnected and removed.

The water in the starboard compartments of the center pontoon will be removed by the main pumps and the dock lifted to light water line. All anchor cables are now slipped, the ends being made fast to four buoys by suitable lines. For holding the dock in position lines are made fast to these buoys and lead up to the capstans on deck at ends of side walls.

Every other keel block will be removed, and the docking

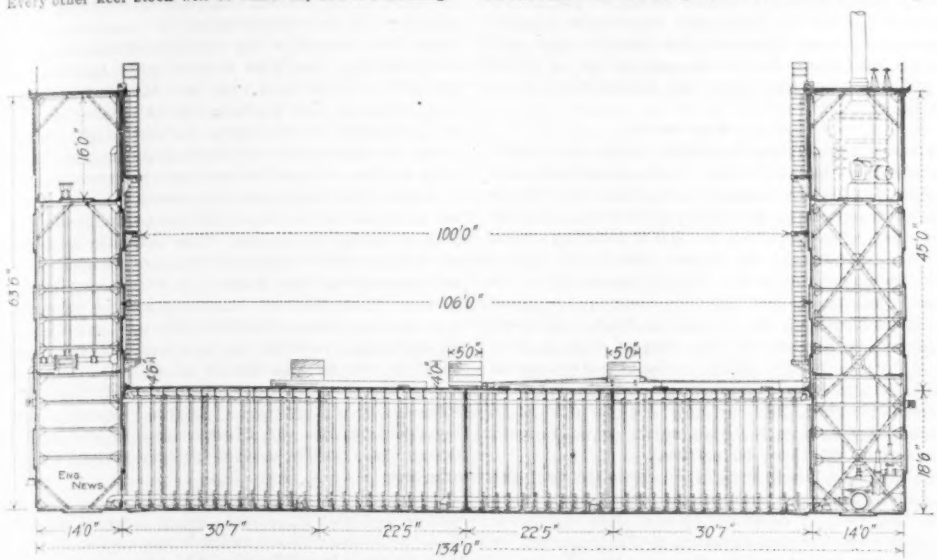


FIG. 2. TRANSVERSE SECTION THROUGH MAIN PONTOON, SHOWING LOCATION OF MACHINERY, PUMPS AND PIPING.

keel blocks will be adjusted so as to support the end pontoons under the transverse bulkheads. The top blocks will be capped with ordinary pine plank 3 ins. x 12 ins. spiked thereto for protection of the oak blocking.

The bolts in all connections between pontoons will now be removed and sufficient water admitted to the end pontoons until a fair clearance is obtained between the connection angles. The end pontoons will then be warped out by the capstans and hawsers and turned around ready to enter the center pontoon between the side walls. The center pontoon is now sunk down to a depth sufficient to give about 1 ft. clearance between the top of blocking and bottom of end pontoon, and the pontoons are warped in over the center pontoon and held centrally so that the docking keel blocking will come directly under the transverse bulkheads.

The center pontoon is now pumped up by the main pumps equally from all compartments until the deck is 1 ft. or more above the water line. The bottom and the lower sides of the end pontoons can now be inspected, cleaned, painted or repaired, all parts being easily accessible, with ample working spaces all around the pontoons.

While inspection of the bottom of the end pontoons is going on the blocking on the deck of the end pontoons shall be adjusted so as to carry the center pontoon directly under all longitudinal bulkheads. Every other keel block will be removed, and all top blocks will be capped by 3-in. x 12-in. pine planking.

The center pontoon will now be lowered by admitting water freely to all compartments until the end pontoons are floating free, when they are warped out by the capstans between the side walls and held clear of the center pontoon, which is then pumped up to light-draft water line by the main pumps.

The end pontoons are now floated out, turned around and sunk down sufficiently to be warped under the center pontoon side walls, water being admitted through the flushing valves in the end compartments.

The end pontoons will be held by hawsers in their original positions while water is again admitted, and the pontoons are lowered until the deck is about 1 ft. above the water line.

The steam connection between the auxiliary steam pipes and the side walls is now made, the steam swinging joints giving perfect freedom for the pontoon to be moved as required.

The end pontoons are now sunk until a clearance of about 1 ft. between the blocking and the bottom of the center pontoon is obtained, and gradually warped under same.

As soon as both end pontoons are in proper position pumping is commenced by the 12-in. pumps in the end compartments and continued equally from all end pontoon compartments until the bottom of the center pontoon is 5 ins. above water line.

The bottom of the center pontoon is now accessible for inspection or repair, and all parts of the whole dock have been self-docked.

Inspection having been completed, the center pontoon will be lowered by admitting water freely to all compartments in both end pontoons until afloat, when the end pontoons are moved to their original position and pumped up ready for connection to the center pontoon.

All connection bolts are now inserted and the dock heeled to starboard, the main drain-pipe connections on the port side again inserted, the water on the starboard side pumped out by the main pumps, and the dock is again floating in complete working order.

The total length of the dock is 500 ft., and the actual width between fenders is 100 ft. The keel blocks are 4 ft. in height, and with a clear depth of 30 ft. of water over them there will still be a free-board of 11 ft. in the side walls, and this, if occasion demands, can be reduced to 6 ft. Thus a clearance of 35 ft. can be secured and, since the mean draft of our largest war vessels is only 27 ft., it is seen that one could be docked if it were down 8 ft. by the bow or stern. This is an important feature, for masonry docks are not flexible at all, the clearance over their entrances is fixed and on none is it over 31 ft. at mean high water.

The power specified was steam, and the pumping plant was to be designed to reduce to a minimum the vibration in the side walls. Three pumps of the horizontal centrifugal type with 24-in. delivery pipes and designed to operate under 35-ft. head will be used to empty the dock, and these will be driven by three direct-connected compound engines. Three water-tube boilers of 200 HP., nominal, each, will supply the steam. With this equipment a vessel of 16,000 gross tons, with a draft of 30 ft., can be lifted clear of the water in four hours from the time it has taken the blocks. Indicator rods will show the depth of water in all compartments, and controlling valves operated from each engine room will regulate the flow of water; these together with the system of speaking tubes will place the dockmaster in communication with every portion of the structure.

When this dock is completed, therefore, it will be of inestimable value in the event of war, for there will be close at hand a structure in which the largest ship in the navy can be docked and quickly gotten into condition for a naval encounter.

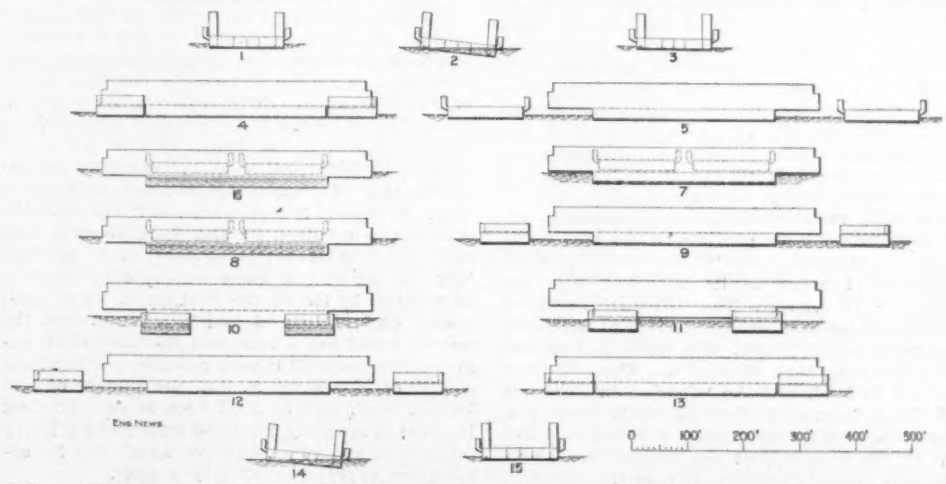


FIG. 3. DIAGRAM SHOWING SEQUENCE OF OPERATIONS IN SELF-DOCKING THE NEW CAVITE DRY-DOCK.

THE USE OF TRUE AZIMUTHS FOR THE DIRECTION OF LAND BOUNDARIES IN THE HAWAIIAN ISLANDS.

A notable innovation in the method of surveying and describing lands has recently been carried out in Hawaiian Islands. It consists in substituting the true azimuths for the familiar courses ordinarily used to denote the direction of a boundary line. The "Pacific Commercial Advertiser" of Honolulu, in its issue of Oct. 27, published a paper describing the new system written by Hon. Philip L. Weaver, Judge of the Court of Land Registration. We quote from this paper as follows:

The surveyor of the Court of Land Registration has included in his rules of survey for the court an important and simple change which will alter descriptions of real property hereafter to conform to the more modern methods of the United States Geodetic Survey. Almost all of the surveyors of Oahu have been interviewed and have approved the change on account of its great simplicity. It is proposed by these surveyors, hereafter, to follow the rule of the Court of Land Registration in their surveys by describing all land by true azimuths. The surveyor of the territory has issued orders that all descriptions of government land be made with true azimuths.

In Prof. J. B. Johnson's "Theory and Practice of Surveying" the following definition is given (p. 11):

The azimuth of a line is the angle it forms with the meridian, and is measured from the South point, South, West, North, East to 360°. It becomes a definite direction when the angle alone is given. Thus the azimuth of 220° corresponds to the compass-bearing of N. 40° E.

The method avoids the many chances of mistake which arise by interchanging the letters E and W in the old method of descriptions. Many errors are made also by describing the line running on the ground, as going north when the intent is to go south. Let us illustrate by reference to an old-fashioned description of Thomas Square, in Honolulu:

Beginning at the south corner of this land and running: 1, north 20 degrees 42 minutes east 650.5 feet along Victoria street; 2, north 58 degrees 12 minutes west 447.6 feet along Beretania street; 3, south 20 degrees 42 minutes west 644.5 feet along Kapiolani street; 4, south 69 degrees 18 minutes east 447.6 feet along King street to the point of beginning.

The new description would read:

Beginning at the north angle of King and Victoria streets, said point being 56.0 ft. from a concrete post at the east angle of King and Victoria streets, as shown on government surely registered map No. 1100, of Kulaokahua, Honolulu, made by C. J. Lyons, surveyor, in 1873, and running by true azimuths:

1—200 deg. 42 min., 650.5 feet along Victoria street; 2—111 deg. 48 min., 447.6 feet, along Beretania street; 3—20 deg. 42 min., 644.5 feet along Kapiolani street; 4—290 deg. 42 min., 447.6 feet along King street to the point of beginning. Area 6 6-10 acres.

It may be noted that this description ties the corner to a government fixed monument, and refers to the surveyor's name with the date of survey, all of which are required by the rules of survey.

This method simplifies the getting of the angle of two lines such as (1) and (2) above. Subtract 111° 48′ from 200° 42′ and the difference, 88° 54′, gives the angle at that corner. It can thus be seen that this method is simpler and more direct than the old one of dividing the compass into quadrants, and describing by them.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

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ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
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ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
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It is about as difficult nowadays to keep up to date in remembering what is the biggest steamship in the world as it was a year or two ago to keep posted on the latest record-breaking heavy locomotive. In order to bring our readers up to date, therefore, we take this prominent place to record the launching on Nov. 21 of the largest vessel afloat, the "Baltic," which is to be added to the White Star fleet of transatlantic steamships. The "Baltic" is a vessel 725 ft. 4 ins. long, 75 ft. beam and 49 ft. deep. Her gross tonnage is reported as about 24,000 and the cargo capacity is about 28,000 tons. She will be propelled by quadruple expansion engines of 13,000 I. HP., and is expected to make about 16½ to 17 knots speed.

This huge vessel represents a considerable advance in size over the previous White Star leviathans, the "Oceanic," the "Celtic" and the "Cedric," each of which at its launching held the world's record for size. The "Oceanic," launched in 1899, is a faster vessel and built with finer lines than the ships built later. She is 705 ft. long and has a gross tonnage of 17,274. The "Celtic," launched in 1901, and the "Cedric," in 1902, are each 700 ft. long, 49 ft. deep and 75 ft. beam, and their respective gross tonnage is 20,904 and 20,980. It will be seen that the "Baltic" has about 3,000 tons greater displacement than the "Cedric," which has hitherto been the largest vessel afloat. All these White Star monsters were built at the Belfast yards of Harland & Wolff.

The "Baltic" represents a type which is now generally agreed to be the most profitable for the transatlantic trade, combining great cargo capacity with large accomodations for passengers, and running at a very moderate speed as compared with the "ocean greyhound" class. For convenience in comparing the size of one of these latter vessels with the "Baltic," it may be noted that the well-known "Deutschland" of the Hamburg-American line has a gross tonnage of 16,200, with dimensions of 684 ft. length, 67 ft. beam and 40 ft. depth.

It is of interest also to compare the "Baltic" with the huge "Minnesota" and "Dakota," now building at New London, Conn., for Mr. Jas. J. Hill. These vessels are rated at 21,000 tons, making them the largest vessels afloat with the exception of the "Baltic." They are 630 ft. long, 73 ft. 6 ins. broad and 56 ft. 1 in. deep. They are thus nearly 100 ft. shorter than the "Baltic," but are nearly as wide, and have a deeper hull. They are said to have an even larger cargo capacity (being rated at 30,000 tons), which is partly accounted for by the fact that they have smaller passenger accommodations (the "Baltic" can carry 3,000 passengers), and their engines are of 10,000 I. HP., as compared with the 13,000 HP. of the "Baltic."

It is a much discussed question where the building of bigger ships is to end. Various authorities in engineering have attempted to predict the future rate of progress in marine construction, and the fact that at a single stroke 3,000 tons has been added to the size of the record vessel will doubtless be made much of. Nevertheless, there is much reason to believe that we are near the limit in size of ships, for the present at least, and there may even be a reaction. The size of ships is governed by the depth of the channel entrances to seaports, and these latest huge vessels draw so much water that they can only enter a few ports and at only a very few can cargo or passengers sufficient to fill them be secured.

Besides this, it will readily be conceded that the reason why bigger and bigger ships have been built is purely a commercial one. The question, "Will it pay?" is the question to be answered in determining whether the size of ships is to go on increasing, and if so to what extent. It will be readily granted that a ship of 10,000 tons can be operated more cheaply per ton of freight carried than one of 5,000 tons, provided the volume of traffic is sufficient to keep her employed, and provided also that cargo handling appliances are such as to keep down delays in port. But granting this, it will readily be seen that there is not a like saving to be made in again doubling the size and going from 10,000 to 20,000 tons. Perhaps under certain circumstances the 20,000-ton vessel may be worth while, but even if this is the case, it does not follow that a still bigger vessel would be still more profitable. It must be remembered that these very large vessels cost considerably more to build per ton of freight capacity than vessels of modern size.

The case is really very similar to what is frequently experienced in other branches of engineering. Take for example the duty of pumping engines. Suppose it is desired to install a pumping engine of 10,000,000 gallons daily capacity. An engine of old-fashioned design in poor repair may develop only 25,000,000 ft.-lbs. duey. If this can be increased to 75,000,000 duty by installing an improved type of engine, the gain will be worth a large investment to secure, since only one-third the coal will be required. Further improvements may raise the duty by 50,000,000 more, or to 125,000,000; but the saving made will be only one-fifth as great as by the change first made. If the first engine used 15 tons of coal in a given time, the second would use 5 tons, and the 125,000,000 engine only 3 tons. If it were possible now to attain a duty of 175,000,000 ft. lbs., the amount of coal burned would still be 2 1-7 tons, so that this last increase in economy, produced perhaps by a heavy investment and at considerable added cost for attendance, saves after all only a trifle.

Just as an engine may be so economical that it may not pay to install a higher-duty machine, so a great ship may carry freight so cheaply that there is a mere trifle to be gained by making a still larger vessel, a trifle that may be much more than counterbalanced by expenses due to the vessel's extraordinary size.

Of all stable and immutable things in this world of change, perhaps the one which we are accustomed to look upon as most permanent and least subject to variation is the level of the ocean, or sea level, as it is commonly termed. Engineers, however, are well aware that the operation of finding the mean or average sea level at a given site is far from an easy one. There are not only the daily variations in the surface level due to tides and waves, but the variations in the height of tides with different parts of the lunar month and different seasons of the year.

An exhaustive study of the variations in sea level in the vicinity of New York city has recently been carried out by Mr. Geo. W. Tuttle, Assistant Topographical Engineer, connected with the Public Works Department of the Borough of Richmond. When the engineer or geologist finds evidence of an advancement or recession of the coast line along the sea shore, it is customary to conclude that the land at that point has risen or subsided as the case may be. Mr. Tuttle points out, however, that a change in the coast line may be produced by a change in the height of the ocean as well as by the vertical movement of the land, and he collates evidence from a great variety of sources to determine how much variation may be ascribed to the level of the ocean surface at a given point on a coast. The evidence on which he places chief reliance, however, is that from self-registering tide gages. At Governor's Island, in New York Harbor, a self-registering tide gage was operated from 1853 to 1879, and from one at Sandy Hook, records are available for the years 1876-'81, '82-'84 and '86-'88, as well as records at numerous other points in New York Harbor since. From a study of these records, together with records obtained in Europe and in the Indian Ocean, Mr. Tuttle arrives at the following conclusions:

(1) That the mean sea level oscillates in an irregular manner and with an average period of about 8 years. Those oscillations closely resemble one another at many ports distant from each other, and appear to be largely due to changes in atmospheric pressure.

Superposed upon these oscillations are irregular ones of shorter periods, which are due to changing barometric pressure, winds, evaporation, influx of river water and other local causes.

(2) The above oscillations compensate themselves completely in the course of time, and do not give rise to a continuous movement in a given direction.

(3) That in addition to the above movements of the sea some ports show a more or less continuous rising of the sea relatively to the adjacent land; others a lowering of the sea level in its relation to the land, and still others maintain a constant relation between the two. These latter make it clear that except for the periodic changes noted above, the sea does not change its level, and that the relative changes are due to land movements.

(4) At various ports the rate of change in the elevation of mean sea level referred to the adjacent land has not remained constant, but has varied in a considerable degree. All the observations show that for long periods the rate of change is less than took place in some part of that period, and the evidence is strong that the movement is not continuous, but oscillatory and confined within narrow limits.

(5) The observations at New York city show that since 1875 the land has been subsiding relatively to mean sea level by about 1.45 ft. per century, but from the establishment of the self-registering tide gage in 1853 to that date little or no change had occurred, and it is improbable that the present rate of subsidence will be continued indefinitely.

Apropos of our note two weeks ago regarding the prospects for a great international meeting of engineers in this country next year, the present outlook is that the different societies of Civil, Mechanical and Metallurgical engineers will each "flock by themselves." We recorded two weeks ago the announcement that the Institution of Civil Engineers is to visit the United States next October, and the prospect now is that joint or at least simultaneous sessions will be held by it and by the American Society of Civil Engineers at St. Louis.

At a recent meeting of the Institution of Mechanical Engineers of Great Britain, it was announced that its next summer meeting will be held in Chicago, and the summer convention of the American Society of Mechanical Engineers is also to be held there. The meeting is scheduled for some time in May.

The Iron and Steel Institute's visit to this country is to occur at a later date than either of the other two. It is to hold sessions in New York city in the latter part of October. It is expected that

this society will be represented by a delegation of 200 or more of its membership. If the other societies are to send over anything like such large numbers, it will be evident that a general meeting of all the foreign societies, together with the American societies, who would naturally act as hosts, would furnish a crowd much larger than could be provided with satisfactory hotel accommodations. Even as the case stands, it will be surprising if the St. Louis meetings of the two civil engineering societies does not result in a demand for "rooms with bawths" quite beyond what the St. Louis hotels, crowded as they will then be with other tourists, can provide.

The contract plans for the Manhattan chain cable suspension bridge, which are published elsewhere in this issue, give the first actual details of this notable bridge that have been made public. Unfortunately these plans leave many details undetermined until the contractor completes his shop drawings, but they are sufficiently complete to afford some hours of interesting study to one who is curious to note how one of the most novel bridge designs of recent years has been worked out. Only one or two points of special interest can be mentioned here. The first of these is the use of reinforcement in the concrete anchorages. The mere fact of reinforceed concrete being used is noteworthy ás evidence of the growing popularity of this new structural material. In addition, this particular design is noteworthy for the reason that timber is employed in place of steel for reinforcing the concrete below the level of mean high water. There was some slight fear on the part of the engineer that steel in this location might be attacked by the infiltration of the water, and as the calculated tension to be provided for was so small that timber would handle it quite as well, perhaps, as would steel, the former material was selected. The apprehensions of the engineer seem hardly warranted by any experience we have with embedded steel in submerged concrete structures, and at best timber does not recommend itself as an especially suitable material for reinforcing concrete. These are questions, however, which our readers can thresh out at their pleasure; the only fact that we are concerned to note at present is that timber was used and used for the reasons explained above.

Another point in the designs which deserves notice is the purpose of the hinges in the tower legs. It has been assumed that these were introduced primarily to permit the towers to oscillate with the contraction and expansion of the cables. This is hardly the true explanation. After the bridge is once completed and adjusted the movement of the towers under the most extreme conditions will be exceedingly small and could easily be cared for safety by the flexibility of the tall and comparatively narrow tower legs. In fact, it is considered by the engineer as entirely within the range of possibility that the erection and adjusting wedges and links designed to make the legs self-supporting during erection may be left permanently in place, thus making each leg substantially a rigid column from bottom to top. The primary purpose of the bottom hinges is, therefore, to facilitate erection and to permit easy adjustment during the placing of the cables and suspended structure.

Another feature of the design about which much curiosity has been evidenced is the method of erecting the eye-bar cables. As noted in the article published elsewhere in this issue, this problem is left to the contractor to solve. The plan for doing this, however, at present contemplated by the engineer is in general as follows: Suspended cable erecting platforms substantially like those always used for spinning wire cables are to be constructed. A complete chain of alternately one-bar and two-bar links will then be completed between supports, using full length pins. This chain will be carried by the working platform until finally connected, and then it will be self-supporting. The remaining bars will then be added to the links already begun until the full number has been erected. It is calculated that no difficulty will be experienced in threading the additional bars onto the pins if they be slightly heated to expand them to the proper length. An increase in temperature of barely 80° F., has been computed to be ample to accomplish this object. By this means of erection the greatest load to which the working platforms will be subjected will be that caused by the first chain of one-bar and two-bar links with their pins, and this load will not exceed 550 lbs. per lineal foot of platform.

THE MONEY VALUE OF A TECHNICAL EDUCATION.

The presidential address on "The Money Value of Technical Training," delivered before the American Society of Mechanical Engineers this week, and printed elsewhere in this issue, will be likely to arouse considerable discussion, in private, if not in public. It is somewhat unusual to publicly weigh the advantages of education in dollars and cents, although it is common enough to do so in considering the practical questions of how long a boy shall continue in school and what course of study he shall pursue.

No one will dispute that Mr. Dodge's statistics are probably fairly accurate as a gage of the relative earning power at the present time of typical young men trained in different ways; but it may well be objected that these figures tell only a part of the story, and that they are likely to be misinterpreted by the public.

On the face of the returns, the average man will have a salary of $41 at the age of 30 if educated in a technical school, as compared with $24 a week if he has only a trade school education, or about $16 per week if apprenticed to the machinist trade. Naturally, therefore, the ambitious parent decides that a technical education is the thing to give his son; and naturally, also, the multitude of engineering schools in this country, small and great, are overcrowded with students.

It must be remembered that there is another side to this picture. The four classes of men whom Mr. Dodge represents in his diagram are doing different classes of work, and it is because of this that such a difference exists in their rate of wages. If the graduate of an engineering college cannot find professional or executive work to do he may have to take a foreman's place along with the men from the trade school, or he may have to join the union and work at a lathe alongside the man who learned his trade as an apprentice, in which case the chances are that he will find more difficulty in securing and keeping a job than the man who has been used to the work from boyhood; or again he may even have to step a peg lower and compete with the unskilled laborer.

Accepting this as a fair statement of the case, it follows that whether a technical education pays in any individual case will depend upon the relation between the supply of and the demand for the men of such training. It is undeniably the case that in any industrial establishment there are ten or a hundred places for those who work with their hands to every one place for those who direct the work. Industry is carried on to make profits, not to furnish employment; and if there is a surplus of engineers they will have no better chances for employment than a surplus of laborers, in fact not so good, for they cannot so readily turn to some other occupation.

The lesson to be drawn from Mr. Dodge's statistics, therefore, is not that it pays to give a boy a technical education. It may pay or it may not. What Mr. Dodge shows is that for the boys who get and keep their positions it does pay, and from the point of view of the general welfare of industry it undoubtedly pays.

It may be said, indeed, that from the point of view of the industrial welfare of the nation the more boys trained in technical schools the better, for there will then result competition between them and a "survival of the fittest," whereby the best and ablest will be "naturally selected" for the available positions. This is actually going on all the time, and within reasonable limits no one can object to it. Beyond those limits, however, it involves an amount of suffering, disappointment and loss that can hardly be contemplated with equanimity.

If there are next year, let us say, a thousand places to be filled with graduates from mechanical engineering courses and three thousand men are being educated to fill those places, it follows not only that two thousand will have to suffer disappointment, but that the thousand who do secure positions will be paid lower wages because of the fact that so many are applying for the positions.

It is for this reason that we always feel, whenever the profits of technical training are publicly advertised, like uttering a warning to the youths who may thus be induced to enter the engineering profession. As they look at Mr. Dodge's diagram they will do well to reflect that the average graduate of a technical school who at 30 years of age is earning his $41 a week is earning it by just as hard work as the machinist who at the same age gets $15.30 in his weekly pay envelope. The graduate, to reach the position he holds, has had to devote six years of his life to hard study, during which time he earned practically nothing, and was under heavy expense. He made this investment, moreover, with the risk that it would turn out unremunerative. Perhaps he may prove unfitted for an engineer's life, perhaps in the struggle of competition another man will come out ahead, and leave him to take a subordinate place, or to remain unemployed. If he does succeed in securing his $41 a week position, it carries with it heavy responsibilities and risks. Taking all these things into consideration, the added earnings of the engineer over the laborer represent no more than a reasonable compensation for his expenditure of time and money.

We have taken pains to set forth these facts, not in dissent from or in criticism of Mr. Dodge's interesting address, but in order that it may not be misinterpreted. We would say no word to discourage from an engineering career the boy who is fitted for it by natural ability, and who starts with a clear appreciation of the difficulties and risks before him. Nor would we say one word to dissuade from pursuing a course in an engineering school any young man whose financial circumstances are such that he can well afford the necessary time and money, and who seeks the training as an education and not merely as a means of aiding him to earn a living. It is to a third class that words of warning need to be sounded—the youths who are making sacrifices for an engineering education with no particular fitness to make use of it in after life, and who will set no greater value upon it than can be measured in terms of dollars and cents. It is when it is expended on such men that technical training does not pay.

LETTERS TO THE EDITOR.

Side Door Suburban Cars: Illinois Central R. R.

Sir: I wish to thank you for the further description of our steel-frame side-door suburban cars, together with editorial comment thereon, in Engineering News, Nov. 26. These cars have now been in service three months, and while we are improving and perfecting them in detail, nothing has occurred to indicate the necessity of any change in the main features of the design or construction of the cars.

As illustrative of the great carrying capacity of these cars in an emergency, I would state that during the recent street railway strike, when our suburban trains were heavily crowded, one of these cars on a trip to the city carried 200 passengers, with some room to spare. Based on this experience, we have estimated that one of these cars could in an emergency carry 300 passengers, of whom one-third would be seated.

We are engaged now in the application of electric connections between the side-doors and the locomotive, so that the act of closing the doors will, when the last one is closed, automatically signal the engineman to start the train. We expect this to accomplish material saving in time over the present system of bell-cord signals, operated by hand.

We now have four of the cars in service, with four more to be completed during next month.

Very truly yours, A. W. Sullivan,
Asst. Second Vice-President., I. C. R. R.

Chicago, Nov. 28, 1903.

The Mixing of Concrete.

Sir: The writer once prepared concrete specifications to read somewhat as follows:

The sand and cement shall be mixed dry and turned until the mixture is uniform in color. Water shall be added through a rose nozzle to form a thin paste of the mixture. This paste to be then added to the stone and the whole mass turned until every piece of stone is thoroughly coated, etc., etc.

He is in a position now where he sees many sets of specifications, and there is little deviation from the above requirement. The deviation is only in the wording.

He has seen that kind of work done on one job only.

It was a job he was in charge of, and the contractor was compelled to follow the specifications.

No text books mention any other way of mixing concrete by hand. Engineers go on specifying it, and contractors and workmen disregard them. If it is the right way and the best way, why is it not insisted upon? If it is a wrong way, why do not engineers stop blindly following old specifications?

Only one specification read by the writer called for a different method of mixing. It was for the construction of a dry-dock in San Francisco a few years ago, and Howard Holmes, Chief Engineer for the State Board of Harbor Commissioners, was the engineer. It called for the spreading of the stone in a layer a certain number of inches thick, the covering of that with sand a certain number of inches thick, and covering the whole with a certain amount of cement. The whole to be turned over with shovels until mixed, then wet and mixed again. precisely the method used on 99% of the concrete work done by hand to-day, no matter what the specifications call for.

It is moisture which causes the cement to set. From the instant it is wet the setting proceeds. If this is true then it is wrong to add water until the aggregates are well incorporated. The method hit upon to save labor is then really the correct one.

The stone should be measured in a bottomless box and spread until its thickness in inches equals its parts by volume. Upon the layer should be placed a bottomless box, in which to measure the sand which should be spread evenly over the stone. Upon the sand should be placed the cement (by weight) and this should also be spread evenly. With square pointed shovels the heap should be shoveled to another part of the platform, each shovel being turned so the materials will fall instead of being thrown off. After being turned over twice it should be turned over a third time and on this third round the water should be gently sprinkled on. A fourth turning will get the water thoroughly into it and the shoveling into wheelbarrows gives it a fifth turn. A proper degree of moisture is obtained when a shovel can be drawn over the mass and leave a smooth surface which will not appear wet or quaky. Or when a lot can be squeezed slightly in the hand and when the hand is opened retain its shape yet do no more than dampen the hand without smearing it.

This mixture should then be deposited in place and tamped until it quakes and is decidedly wet on top. If the drop from the wheelbarrows is long and the wall is comparatively thin it should be thrown in with shovels to prevent the aggregates from separating by sizes as they fall.

Is it not a fact that when all ingredients are mixed dry several times there results a better mixture by reason of the heavier materials cutting through masses of the lighter, smaller-sized materials? Is it not better to add the water last?

Yours truly, Ernest McCullough.

Chicago, Ill., Nov. 24, 1903.

The Design of Long Span Suspension Bridges.

Sir: Engineering News of Oct. 1 contains a letter from Bridge Commissioner Lindenthal which purports to be a reply to my paper, published in the same issue of your journal, on the relative strength and carrying capacity of the different East River bridges.

Inasmuch as a copy of that paper, four weeks before its publication, had been submitted to Mr. Lindenthal, giving him an opportunity to study and check my calculations, it was expected that, if he found the results incorrect, he would point out, line for line and figure for figure, where the mistakes are. That he has failed to do so, and that his reply consists merely of generalities and personal opinions which cannot alter the mathematical truths set forth in my article, must be a disappointment to the friends of the eye-bar design.

The question to be decided is simply this: Will the Manhattan bridge, if executed after the present design, be 40% stronger and not over 20% more costly than the Williamsburgh bridge, as Mr. Lindenthal has alleged; or, as I have demonstrated in several publications, will it be 50% weaker than the Williamsburgh bridge and will it cost five millions of dollars more than the latter, if constructed of the same strength as the Williamsburgh bridge?

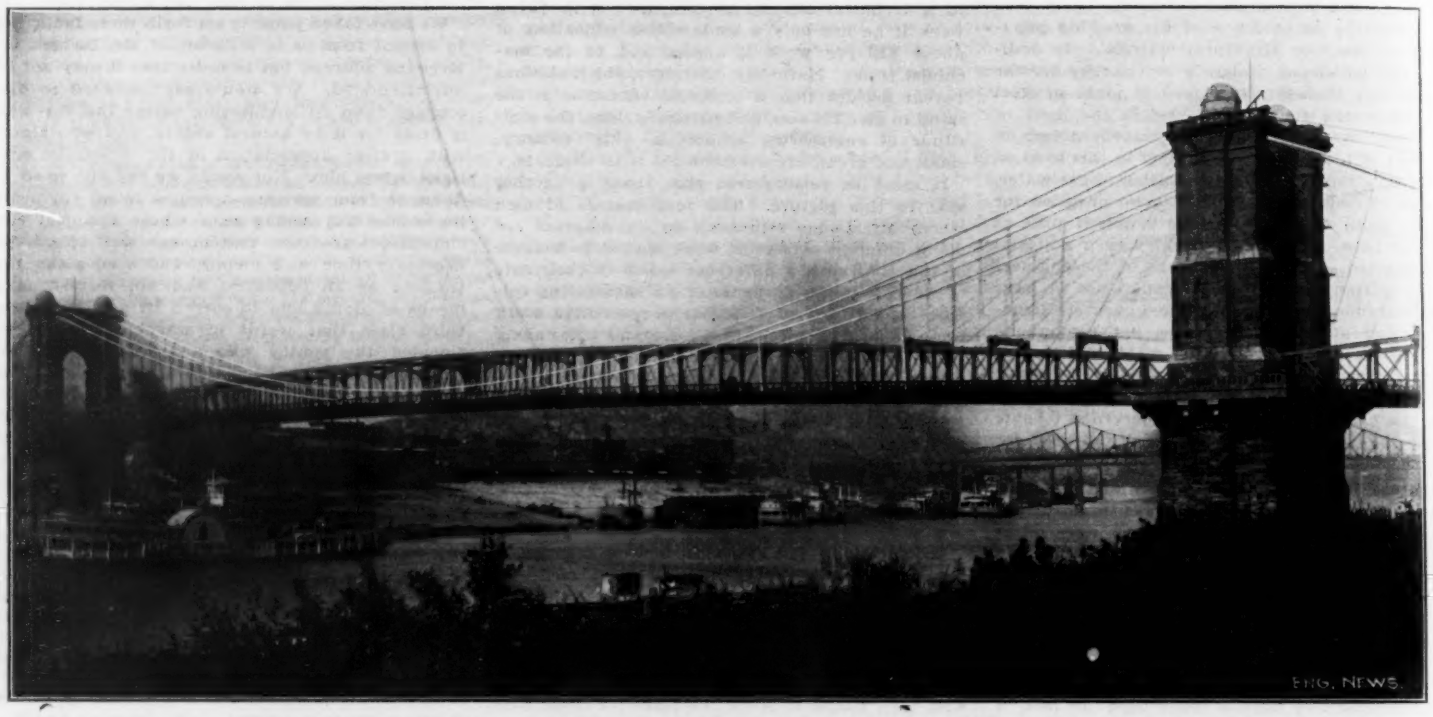
I have shown by figures, based on the actual strengths of steel wire and eye-bar steel, and calculated after well known rules of applied mechanics, that Mr. Lindenthal's assertions are wrong. If they are correct and I am wrong, it is for Mr. Lindenthal to prove it mathematically, and not, as in his reply, by criticising other suspension bridges or derogating my professional knowledge and impartiality, or by setting forth his personal uncorroborated ideas about stiffening constructions or by presenting useless illustrations, showing how the Williamsburgh and Manhattan bridges would look if built upside down! Such arguments do not settle the question of strength and cost of the proposed Manhattan bridge. The latter two points, which, alone, are of interest to the taxpayers of the community, are touched upon very lightly in Mr. Lindenthal's article, and the few remarks relating thereto are misleading or wrong, as I shall point out in the following explanations:

Mr. Lindenthal puts much stress on the circumstance that my estimates, showing the enormous cost of the Manhattan bridge, as published in Engineering News of March 12, had received no notice from the Board of Experts. While this is true, it should also be stated that none of the experts has ever doubted or disputed, and still less disproved, the correctness of those calculations. That no attention was paid to them has another and very simple reason. It must be remembered that the board of experts was not appointed to compare a number of plans and select the best from them, but the experts had merely to decide whether one single plan, laid before them, was practical or not. They were not asked to look on the economic side of this plan or to criticise it for lack of economy, and, therefore, they naturally paid no attention to this question. It will also be remembered, as evidence of the uncertain and experimental features embodied in Mr. Lindenthal's plan, that the experts hesitated, experimented and deliberated for six months before they could come to the conclusion that the plan was at all practical. The final recommendation of this plan can, therefore, not be looked upon as an indorsement, but it became a necessity to adopt the only plan submitted if the city were to have a bridge at all. The same reasoning must be applied to the action of the art committee when it accepted the present design for the Manhattan bridge. There was no alternative plan before them, hence the adoption of the plan is only a negative indorsement, signifying that the design is not so unaesthetic as to disgrace the harbor of New York city. The decision of either committee does not exclude the probability that other designs, for a more economical and more beautiful structure, would have been preferred if they had been allowed to be submitted.

Mr. Lindenthal refers to a "hearing" I had before the experts, in which I had failed to convince them of the correctness of my estimates and calculations. This is a misstatement. The fact is that I was given no opportunity for making such an attempt. The interview consisted of a sort of cross-examination on general engineering matters to which I was subjected, and the question whether my calculations were correct or not, was not at all discussed. The only reference to the subject was the chairman's remark that the unit price I had assumed for the eye-bar chain was probably from two to three cents too high. Subsequent events have shown that the chairman was mistaken. The recent lowest bid (submitted Sept. 21) for the superstructure of the Blackwell's Island bridge at 8.3 cts. per lb. for 40,000 tons of common steel and 5,000 tons of nickel steel has demonstrated that my former assumption of 9 cts. per lb. for all nickel steel bars was about correct, and that, if anything, the price will be higher. The most important part of my paper, the tabulated strength and carrying capacity of the different East River bridges, is commented upon by Mr. Lindenthal very superficially. He alleges that some data which I used were not authentic, that my calculations were based on imaginary standards, and that it is altogether senseless to compare the safety of bridges of different design. I beg to contradict these statements.

All data as given in the table, whether authentic or not, are correct. If not, why did not Mr. Lindenthal point out what is wrong? The same question applies to his remark about "standards" as a base for calculations. If my standards are imaginary, why does he not enlighten the public by stating what the correct standards are? He ought to know, however, that there is nothing "imaginary" about my selection of standards. The strength of steel wire is taken from the official records of about 100,000 tests made with wires from the cables of the Brooklyn and Williamsburgh bridges. The qualities of nickel steel, as assumed in my calculations, are those stated in the final report of the board of experts, and also corresponding with Mr. Lindenthal's recently published specifications for the material of the Blackwell's Island bridge. On the ground of imaginary standards, the correctness of my comparisons, as tabulated, can, therefore, not be disputed! That it is senseless to make such comparisons, on the ground of differences in the general designs, is probably the isolated opinion of Mr. Lindenthal.

As Mr. Lindenthal seems to be unable to meet the main objections which were raised against his design, he enlarges on small matters and attributes to me statements and opinions which I have never expressed. I will, therefore, repeat my original, and only, standpoint in this controversy, which I have taken as long as eight months ago, namely, that the Manhattan bridge, after the present design, will be relatively the weakest of all East River suspension bridges, existing and proposed, and that it will cost some five millions of dollars more than the Williamsburgh bridge, if constructed as strong as the



SUSPENSION BRIDGE OVER THE OHIO RIVER AT CINCINNATI. Wilhelm Hildenbrand, Chief Engineer.

latter. These are the points to which I have confined my arguments and calculations. Incidentally, I have also commented on the stiffening construction of the Manhattan bridge which Mr. Lindenthal considers the great feature of his design and on which the claim for its superiority is based. I have maintained, and still maintain, that it is bad engineering to construct a bridge in which the principal member, so to say the backbone, of the structure is weak while a secondary, rather subordinate, part of the same is unusually and unnecessarily strong!

Mr. Lindenthal criticises and minimizes my works, among which there are several suspension bridges of over 1,000 ft. span. One of these, crossing the Ohio River between Cincinnati and Covington, is singled out for a specially severe criticism, and I take, therefore, this opportunity for presenting an illustration of this bridge and to say that in magnitude it stands second among the great suspension bridges and third among all the great bridges of the world. This bridge, resting on the old piers, but otherwise entirely new, was constructed at a reasonable cost, is satisfactory and profitable to the owners, and in point of rigidity it offers all that is wanted by the public, though I gladly acknowledge that it is not as rigid as solid rock, and that it can not be placed upside down without collapsing! Wilhelm Hildenbrand, C. E.

Mapimi, Mexico, Oct. 26, 1903.

(A proof of the above letter was submitted to Bridge Commissioner Lindenthal, and we append his reply.—Ed.)

Sir: Those who are versed in the subject know that a discussion of the relative merits of wire cables and eyebar chains for suspension bridges on mere hypothetical grounds is entirely valueless. The only comparison between different designs which can have conclusive value must be on the basis of fully worked out strain sheets for any given case, on an agreed basis of unit stresses. Every experienced bridge designer knows this to be incontrovertibly true, even for ordinary trusses of longer span, and still more necessary in the case of arch and suspension bridges.

Mr. Hildenbrand has made no design for either a wire cable or for a chain structure for the Manhattan Bridge. All he did was to take the Williamsburgh bridge, which is a combination of wire cables with stiffening trusses (and not designed by him), and to deduct therefrom by the rule of three, in his own way, uncorroborated by any authority on designing, the dimensions of a chain bridge.

That process, called by Mr. Hildenbrand "a calculation after well-known rules of applied mechanics," reminds one of the similar reasoning by which it was claimed at one time with equal confidence, that no steamer could be built strong enough to carry coal sufficient for crossing the Atlantic Ocean.

There is no difficulty in "proving" that the chain bridge will cost many million dollars more than a wire cable bridge. All you have to do is to suitably adjust the premises as to factors of safety the elastic limits of cables, the degree of rigidity for the stiffening trusses and similar details; and, if "no experts have ever doubted or disputed, and still less disproved the correctness of the calculations." then they must necessarily be true, regardless of whether or not the experts think the matter worth disproving.

Nevertheless, I believe that if Mr. Hildenbrand, deeply solicitous for the taxpayers of New York, desires to furnish "proof" of the wastefulness of chain cables over steel wire cables, that will be accepted as such by disinterested experts, he ought to show, if he can, in what particular respect the chain design for the Manhattan Bridge, of which I herewith send the plans, strain sheets and specifications for publication, is inferior to a wire cable bridge of equal capacity and rigidity, based on the same unit stresses for the different parts of the structure, and on the same relative value of wire cables and chains.

What is that relative value? Mr. Hildenbrand insists that the unit stresses in cables shall be based on the elastic limit of the material. Let us see whether that was the rule followed in the Brooklyn and Williamsburgh suspension bridges which he holds up as examples.

The four wire cables of the Brooklyn Bridge have, according to Mr. Hildenbrand: A breaking strength (on 590.4 square inches) of 52,248 tons, and an elastic limit of 45,164 tons. They are fastened to wrought-iron eyebar chains, having an aggregate section of 2,052 sq. ins. The eyebars, mostly 9 × 3 ins., have never been tested, because there was then no testing machine in existence big enough for that size of eyebar. A larger breaking strength than 24 tons and elastic limit of 12 tons for such large bars could, however, hardly be expected. Therefore the breaking strength of the anchor chain may safely be set down as 2,052 × 24 = 49,248 tons, and the elastic limit at 24,624 tons, which is little more than half the elastic limit of the cables. This is evidence that the relative values of wire cable and chain were not based upon their elastic limits.

For the wire cables of the Williamsburgh Bridge Mr. Hildenbrand gives the following figures:

Breaking strength of cables (891.28 sq. ins.)	90,761 tons.
Elastic limit of cables	84,672 "

These cables are fastened to anchor chains of eyebars, made of structural steel having a total cross section of 2,736 sq. ins., and exposed to the same maximum strain as the cables. From 23 recorded tests, the average breaking strength of the eyebars is 28.5 tons and the elastic limit 15 tons per sq. in. Hence breaking strength of anchor chain 2,736 × 28.5 = 77,976 tons; elastic limit 2,736 × 15 = 41,040 tons.

The elastic limit of the cables is here 8% larger than even the breaking limit of the anchor chains, and the elastic limit of the anchor chain is less than one-half (48½%) that of the cables. Here, again, we have evidence that the relative values of eyebars and wire cables were not based upon the elastic limit.

It is obvious, that based upon the elastic limit of the anchor chain, which is an essential part of the cable, the two bridges have only one-half the strength claimed for them by Mr. Hildenbrand in his misleading table.

However, engineering judgments (my own not considered) may differ as to the margin to be allowed in wire cables (composed of several thousand wires) for the uncertainty of strain distribution for local bending, and for inaccessible corrosion in the interior, it is undeniable that in the Williamsburgh bridge, selected by Mr. Hildenbrand as a model, that judgment is recorded to the effect that 2,736 sq. ins. of structural steel are equivalent to 891.28 sq. ins. of steel wire. As nickel steel is 50% stronger than structural steel, we would have 2,736 sq. ins. of structural steel equal to 1,824 sq. ins. of nickel steel equal to 891.28 sq. ins. of steel-wire cable as a deduction from the Williamsburgh Bridge. That is very nearly in the proportion of 3 to 2 to 1 of useful cross section.

Has Mr. Hildenbrand, in accordance with his theory, made the elastic limit of the new anchor bars in the Cincinnati Bridge, which he repaired, equal to the elastic limit of the cables fastened to them? Or has he applied his theory to the several suspension bridges of over 1,000 ft. span, which he says are among his works? Or is there a single instance of its having been applied by any one else?

It is much less trouble to prove a design, by the rule of three, to cost five million dollars too much, than to make a painstaking analysis and to work out the strain sheets in its verification. Without such verification, however, the claim has not a leg to stand on.

The Manhattan Bridge has nothing in common with either the Brooklyn or the Williamsburgh Bridge. It is not in imitation of either, and it is not a suspension bridge stiffened by haphazard methods, but a scientifically prepared design, in which no member can be overstrained from the assumed exceptionally large, but full justified emergency live load of 16,000 lbs. per lin. ft. of bridge, covering the whole or any one part of it, as recommended by the Board of Experts. The regular working load of 8,000 lbs. does not strain any part of the metal more than one-third its average breaking strength, or two-thirds of the elastic limit, also in accordance with the recommendations of the Board of Experts, and with advanced knowledge for the designing of long span bridges.

It should be noted, that the calculation of the system chosen for the Manhattan Bridge is free from the ambiguities which beset the distribution of loads in the usual combination of cable and suspended stiffening truss. It is impossible to determine with accuracy how much of the load is carried near the towers by the cable, and how much by the truss, because the long suspenders elongate under the action of the live load.

The calculations for the Manhattan Bridge have been independently checked and the results have closely agreed.

Mr. Hildenbrand seems to have a grievance against the Board of Experts, whom he accuses of having "hesitated, experimented and deliberated for six months" on the "uncertain and experimental features" of the plan for Manhattan Bridge. How does he reconcile that allegation with the following paragraph of their report, dated June 29, 1903?

> The strength of steel eyebars having the above qualities will be 50% greater than standard bars now used in the best class of bridge construction; the working strains can therefore be increased in the same proportion.
>
> In our preliminary report of March 9, we reported favorably on all features relating to the design of this bridge, subject only to the uncertainty of obtaining this quality of material. This uncertainty is now removed.
>
> In this final report, we unanimously recommend the adoption and execution of the proposed design of the Manhattan Bridge, as submitted to us by the Commissioner of Bridges.

This deliberate opinion of weighty and impartial experts was rendered after they had heard Mr. Hildenbrand at his request, and when they were fully acquainted with his objections, theories and "proofs," submitted to them in writing.

Mr. Hildenbrand continually deprecates the qualities of nickel steel, speaks of little specimen tests, when tests with annealed full-sized bars were specially stated, and claims a superior knowledge of a material which he had never taken the trouble to investigate with the steel makers, who would no doubt furnish him as readily with their experience and information of the tests made, as they did the Bridge Department and the Board of Experts.

I wish to call particular attention to the specifications for nickel steel eyebars. The elastic limit of 48,000 lbs. and the ultimate limit of 85,000 lbs. per sq. in. are not averages, but *minima* requirements for full-size bars after having been annealed. The averages will necessarily exceed those limits. The minima requirements for the full-size eyebars of structural steel are 28,000 and 56,000 respectively. The nickel steel eyebars will therefore be more than 50% stronger than those of structural steel.

In my comparison of designs, one with eyebar chains, and the other with wire cables, published in Engineering News of June 25, I had stated the price of nickel steel eyebars put in place at 6½ cts. and of structural steel at 5 cts. Those prices were obtained from authentic sources and were considered reliable at the time. Later and recently, however, there has been such a rapid increase in the cost of erection of structural steel work of all kinds, by reason of large increase of wages, labor agitations and frequent strikes, that some of the largest firms refuse to bid at all at this time on any kind of structural work in New York. Those that did bid on recent steel structures and on the Blackwell's Island Bridge sought safety in high prices. The nickel steel eyebars cost 8.03 cts. per lb., and eyebars of structural steel 6.52 cts., a difference of 1.51 cts. per lb. As all structural work, including wire cables would be affected in like manner by the higher prices, the difference in cost between eyebar chains and wire cables would remain relatively the same, and it does not affect the conclusion of my comparison published in your issue of June 25, namely, that the cost of a bridge with eyebar chains of nickel steel for the Manhattan Bridge does not materially differ from that of a wire cable bridge of equal capacity.

In confirmation of these conclusions, I refer to the result of a recent similar comparison of designs for a bridge in Cologne, Germany. The Harkort company made designs for a wire cable suspension bridge over the Rhine and also for an eyebar chain bridge, and found no marked difference in the cost of the two designs.

A like conclusion as to cost and time of erection had been arrived at for the new Buda Pest suspension bridge (statements to the contrary notwithstanding), where the preference was given, after years of investigation and comparison, to a chain bridge with eyebars, because, all conditions considered, it was not more expensive than a wire cable bridge, and because of the most satisfactory experience with the famous old chain bridge; which, in the 54 years of its existence, has required no repairs except to the woodwork and paving.

The question of wire cables vs. eyebar chains was searchingly investigated in all these three instances—the new Buda Pest Bridge, the Cologne Bridge and the Manhattan Bridge—by independent designers, unknown to each other. The same result was obtained in each case, namely, that a chain bridge, besides having the great advantages of quicker erection, cheaper maintenance, and greater durability is no more expensive to build than an equivalent wire cable bridge. The Manhattan Bridge shows this to be true for a span up to 1,500 ft.

A fact not foreign to this discussion, but perhaps still more surprising to some engineers, was established in the competition of designs for the railroad bridge at Quebec over the St. Lawrence River; a cantilever design was cheaper up to 1,800 ft. than an equivalent suspension bridge design with steel wire cables. Therefore if economy alone were to be considered, in the interest of the taxpayers for whom Mr. Hildenbrand professes to speak, then a cantilever design for the Manhattan Bridge would be preferable to either a steel wire or eyebar suspension bridge.

I append herewith a table of comparison of the weights of metal for the nickel steel chain design and of two wire cable designs of Manhattan Bridge, based on the same sag of cable = ⅛ of the center span. The first is the approved chain design with stiffening frame attached to chain, the second is a wire cable with same system attached to cable, and the third is the usual combination of cable and parallel chord stiffening truss. Nickel steel is used for the heavier sections of the stiffening frame in all three designs, it being an economy to do so, notwithstanding the higher price of nickel steel. That reduces the amount of steel required for the stiffening trusses, as given in my table published June 25, and also lightens somewhat the chains and wire cables given then.

The unit stresses in the floor construction, bracing, towers and stiffening frames are the same in all three designs and are stated in the specification, sent herewith. For the nickel steel eyebar chains and the steel wire cables the unit stresses in pounds per square inch compare as follows:

	Eyebars.	Wire cables.
For dead load	23,000	46,000
For live load of 8,000 lbs.	30,000	65,000
For emergency load of 16,000 lbs.	39,000	84,000

The *average* breaking strength of the hard steel wire cable is taken to be 2.15 times greater than the *average*

of annealed nickel steel. The harder and stronger the steel wire, the closer is the elastic limit to the breaking limit. In very hard wire the elastic limit is almost indistinguishable from the breaking limit. Hard steel wire elongates only 2 to 3% before breaking. Annealed nickel steel bars elongate at least 9% before breaking.

If smaller unit stresses in the wire cables are desired, then those in the nickel steel eyebars should also be correspondingly reduced, but there appears no valid reason for doing so. It would make the bridge only heavier than it needs to be. A strong cable combined with weak stiffening does not make a better bridge, and was excusable only when engineers did not know how to calculate a suspension bridge correctly.

On the correctness of the universally accepted theory, that the breaking limit and not the elastic limit is the proper basis for the unit stresses, I quote by translation from Professor Tetmajer's work, "Elasticitaets und Festigeitslehre," page 221, which is generally accepted as high authority:

The elastic limit cannot be utilized for the determination of unit stresses, for the reason, that in some materials a fixed elastic limit does not exist, and in other materials it is dependent upon accidents of production and manufacture, and hence is variable. Therefore, no choice is left, but to use the cohesion limit or breaking limit on which to base the unit stress with sufficient safety against rupture. Therewith goes the tacit condition, that the unit stress, so determined, shall be within the elastic limit, and that for materials without a law of elasticity, the unit stress be sufficiently small to resist repeated stress without change.

Comparison of the weight of steel in superstructure of three designs of same capacity and on the basis of same unit stresses. Spans 725 ft.—1,470 ft.—725 ft. long; sag of middle span ¼ of the span:

	Eyebar design with stiffening frame attached to chain.	Wire cable design with stiffening frame attached to wire cable.	Wire cable design with stiffening trusses, having parallel chords, 55-ft. high, c. to c.
	lbs.	lbs.	lbs.
Floor system and bracing (structural steel)	29,070,000	29,070,000	29,070,000
Towers (structural steel)	16,800,000	16,430,000	16,600,000
Eyebars with pins, or wire cables, with cover and web fastenings	28,400,000	12,030,000	11,530,000
Stiffening frames (half nickel steel, half structural steel)	15,160,000	21,430,000	27,500,000
Totals	89,430,000	78,960,000	84,700,000
Deflection of center span under live load of 16,000 lbs. per lin. ft. with the side spans unloaded	24 ins.	36 ins.	57 ins.

In the original design having spans as follows: 850, 1,465, 850, the deflection would have been much larger.

It must be constantly borne in mind that the sections in the stiffening frames depend upon the deflections, and that the deflections depend upon unit stresses, other things being equal.

In the eyebar bridge the working load of 8,000 lbs. covering the whole bridge will increase the strain in the cable (30,000 — 23,000) = 7,000 lbs. per sq. in., and the emergency load (39,000 — 23,000) = 16,000 lbs. per sq. in.

In the wire cable bridge the working load will increase the strain in the cables (65,000 — 46,000) = 19,000 lbs. per sq. in., and the emergency load will increase it (84,000 — 46,000) = 38,000 lbs. per sq. in. Elastic elongations are in proportion to the unit stresses.

The wire cable will, therefore, extend elastically more than twice as much as the eyebar cable. The stiffening frame must bend with the cable and hence must undergo greater elastic deflections, which result for the same unit stress in heavier sections. The result is reflected in the above table. The time of calculation by the rule of three in such structures has gone by forever.

G. Lindenthal.
Commissioner of Bridges.

New York, Dec. 4, 1903.

One Reason Why Large American Cities Have Adopted the Reduction Process of Garbage Disposal.

Sir: In your issue of Nov. 5 editorial comments are made upon a paper by Messrs. Winslow and Hansen on garbage disposal, in which paper they conclude that one of the main objections to the reduction system is that offensive odors make it a nuisance.

In the reduction plant operated in this city all nuisance has been eliminated by a system of suction fans and piping which maintains a continuous draft through doors and windows from without the factory to within it and into the base of the smokestack, thus preventing escape of air from the factory except through the chimney, where all impurities are destroyed. This plant is well within the city limits, and the main objection to its location is the concentration of arriving garbage wagons—a sentimental objection applicable to any location, either within or without the city limits.

Reduction plants require a separation of organic matter, mainly kitchen wastes, from ashes and rubbish; cremation plants require their mixture; the latter are about eight times the former in quantity. In this country nearly all large cities, where long hauls are necessarily unavoidable, pay for the collection and disposal of garbage only, and this largely accounts for the general use of the reduction system in nearly all cities of a population of about 100,000 or more. In the small cities the quantities, both of garbage and other domestic waste, are so much smaller and the hauls so much shorter that cremation plants seem best adapted to their use. Very respectfully,

E. A. Hermann, M. Am. Soc. C. E.
Security Building, St. Louis, Mo., Nov. 25, 1903.

(We agree with our correspondent in the main, but do not consider it necessary to mix ashes with garbage, paper and the like wherever cremation is employed. In fact, only a few garbage furnaces in this country treat ashes. Until public sentiment is changed, to say the least, long hauls will be required for garbage, whatever the method of disposal, and herein lies the strength of the point made by Mr. Hermann. Generally, ashes can be disposed of by means of a short haul, but mix them with garbage and then the ashes, also, must have a long haul.

The concentration of garbage wagons is a factor that must be considered regardless of the location of the disposal plant or the method of disposal adopted.—Ed.)

The Economic and Sanitary Aspects of Garbage Disposal.

Sir: You were good enough, in your issue of Nov. 5, to notice rather fully an article on "Some Statistics of Garbage Disposal for the Larger American Cities in 1902," presented by Mr. Paul Hansen and myself at the Washington meeting of the American Public Health Association. Although dissenting from our conclusions on the ground that we have laid too much stress upon sanitary considerations and have in general failed to prove our point, that "the cremation of mixed refuse appears to be the most generally satisfactory process," your review is in general so fair that I am tempted to trespass upon your courtesy for a further statement of my own position.

The principles underlying the problem are in my judgment two in number. (1) The disposal of garbage should be accomplished as cheaply as possible. (2) It should be accomplished as far as possible without nuisance. You believe the importance of the second principle has been overestimated and quote to that effect Dr. C. V. Chapin, whose recent onslaughts on some of the fetiches of sanitary science have been welcomed by no one more than by the writer. Nevertheless, in the passage you cite Dr. Chapin says: "Garbage should be collected with the least possible nuisance and disposed of with the least possible nuisance." He adds: "But it should also be done with some regard for economy." I have gone a step further and placed economy first. Surely, however, the second qualification of a disposal process should be its freedom from offense; else why collect and dispose of garbage at all? The wastes of the kitchen might be thrown into the street or the backyard and there left to decompose without any serious immediate effect on the health of the community, yet the public demands, for its comfort and convenience, that such material should be removed, and those sections of it in the neighborhood of disposal works are strong in the opinion that the nuisance should not be merely localized. That is one of the "popular ideas" which you apparently consider that we have "taken too seriously." For my own part I certainly believe that the personal discomfort and the damage to real estate caused by an unsuccessful garbage plant are sufficiently serious to demand attention next after expense in the consideration of any plan for the disposal of waste materials.

With regard to the cost of operation, there are three systems to be compared: The reduction of garbage; the cremation of garbage alone, and the cremation together of garbage, ashes and combustible waste. From our study of the cost of the first two systems to American communities in 1902 we concluded that

on the whole it appears that the bonus paid to a reduction company is never much less than the amount required to operate a city cremator of the American pattern, and, as in the case of Syracuse and St. Louis, may be a great deal more. Economically considered, the two systems are fairly well balanced.

To this conclusion I do not understand that you take any exception. Furthermore, we suggest the probability that the European system of cremating all mixed refuse together would probably be cheaper than either reduction or cremation as practised in America. This is still a matter of opinion, but it is, I believe, the opinion shared by most of those who have compared conditions on the two continents. The most exhaustive examination ever made of this question (by Mr. Hering's committee in 1897) led to the following conclusions: With regard to the treatment of garbage by itself or in conjunction with other waste materials,

a separation does not seem to be economical or advisable, unless the conversion of garbage into saleable products is an assured profitable business.

When no separation is made of the various waste materials and all are collected together, there is, in the opinion of your committee, but one way in which the final disposal should be accomplished, namely by cremation.

The results of experience, now before your committee, indicate that the English pattern of cell furnaces, with sloping ante-chambers, give more economical results than the large and level American furnaces.*

If later evidence has modified these conclusions it should be clearly presented to the engineering public. At present the burden of proof would seem to rest on anyone who should claim superior economy for garbage reduction. The evidence thus far published seems all to harmonize with our statement that the cost of this process is not less on the average than that of cremation.

Granting that the economical advantages of the systems are fairly well balanced, their respective sanitary efficiency must turn the scale in favor of cremation, according to our view. This is the point at which you take issue with Mr. Hansen and myself, and it is in regard to this preference that you consider more detailed arguments would be in order. Such arguments as to the sources of foul odors inherent respectively in the cremation and reduction might easily be made; but they will at once occur to anyone familiar with the two types of plant. The crucial test is not furnished by a priori reasoning, but by practical experience. Of the authorities reporting in our investigation most of those in cities with reduction works have significantly ignored the question as to the occurrence of complaints, the Health Commissioner of Buffalo alone reporting "none." Dr. Chapin, however, will surely be accepted by you as free from that personal bias which you deprecate; and reference to his classic work on "Municipal Sanitation in the United States" will show that he refers to the Buffalo works as "quite offensive," mentions "a good deal of offense" at Pittsburg, notes "little attempt to prevent nuisance" at Cleveland and Boston. He considers conditions fairly satisfactory at St. Louis, Cincinnati and Syracuse. It is significant to note that two of these three cities stand at the head of the list in point of cost; Syracuse paying $2.16 and St. Louis $1.86 a ton for disposal. It is perhaps hardly fair to quote Mr. J. B. Taylor's account of the Philadelphia plant, so long ago as 1896;† but the following sentence is worth remembering: "The characteristic caramel odor is capable of a range, flatness of trajectory and penetration equal to that of our modern coast defense rifles." It was only in 1902 that Dr. Soper wrote of the New York plant as follows:

Numerous complaints have been made by property owners in the vicinity of Barren Island that offensive odors emanate from the works which have an injurious effect upon the health of citizens and the value of property for a distance of ten miles from the plant.‡

The storm of complaints excited by the Boston works, culminating in an injunction against its continuance in the original location, are familiar to your readers; but since you dismiss Dr. S. H. Durgin's pithy comparison of the reduction and cremation system, "the one is a nuisance and the other not always a nuisance," with the comment that he is "strongly prejudiced against reduction," it seems only fair to state that his "prejudice" is perhaps justified by long and bitter experience. The only health officers who seem contented with this method of disposal are in cities whose plant is located within the borders of some less favored community. Thus the Detroit works are situated "many miles out of the city;" the Pittsburgh works 28 miles, the Washington works 30 miles from the city. Of this practice Dr. Woodward, the able health officer of the latter city, writes as follows:§

As the prevention of complaint from residents in the vicinity is always a matter of considerable expense in the cost of operating a reduction plant, it might seem at a first glance as though this were the ideal solution. It remains to be seen, however, whether the increased cost of transportation does not more than offset the cost of operating such an establishment in a more or less sanitary manner nearer the point of collection.

It is most certainly true that cremation also may and often does create a nuisance; but are the complaints anything like so general? In the investigation by Mr. Hansen and myself the health commissioners of the following cities reported no complaints from works of this character: Bridgeport, Fort Wayne, Joliet, Lancaster, Memphis, Milwaukee, Minneapolis, Scranton, Terre Haute, Trenton, Yonkers and Youngstown. At Atlanta, "there have been complaints about the odor arising from the plant." At Portland, Ore., it is said that complaints are "very few and none when care is exercised in operation." At San Francisco "there have been a few complaints emanating from the smoke coming from the chimney in damp weather." I question if anyone will deny that cremation plants have caused on the whole less nuisance than reduction plants.

With regard to the European type of cremator the evidence as to sanitary efficiency is quite conclusive. The experiments at Hamburg showed seven years ago that mixed refuse could be cremated with practical freedom from nuisance and the universal English opinion is summed up by Maxwell in his work on "The Removal and Disposal of Town Refuse" as follows:

Oftentimes, were it not for the great prominence in the landscape of a tall chimney shaft, the existence of a refuse destructor in a neighborhood would not be gener-

*Transactions of the American Public Health Association for 1897.
†Report of the Brooklyn Health Department for 1896.
‡Transactions of the American Public Health Association for 1902.
§Transactions of the American Public Health Association for 1901.

ally known by the inhabitants. At the present time there is no reason whatever why a destructor, properly designed and managed, should be a source of the slightest nuisance.

It has been the fashion of late to confine discussion of garbage disposal problems to oracular statements as to the necessity for adapting special methods to each locality under expert engineering supervision. That is unquestionably a wise generalization. Yet experience furnishes certain general conclusions which are useful in settling specific questions for the future. In sewage disposal, for example, the costly experiments of numerous English communities have taught the lesson that chemical treatment is not economical except under special conditions, such as obtain with the acid-iron sewage of Worcester. So it seems to the writer that the teachings of experience with regard to garbage disposal should not be swept aside with an off-hand reference to the paramount importance of local conditions. You speak, I fear with double meaning, of our Washington paper as "the most recent illustration of the unsatisfactory condition of garbage disposal in this country." Is it not worth while to consider whether the unsatisfactory condition of garbage disposal in this country, as contrasted with the very satisfactory progress of that art in England, is not due to the fact that the English method is fundamentally a better method than our own? Let us by all means have the most exhaustive possible study of the peculiar factors in each special community; but let us not, as we have in the past, ignore in our calculations the one method which has acquitted itself with a fair degree of uniform success, the cremation of unseparated refuse in the English type of furnace.

C.-E. A. Winslow.

Massachusetts Institute of Technology, Boston, Mass., Nov. 19, 1903.

(It appears from the foregoing letter that our correspondent is in substantial agreement with us in the opinion that garbage disposal has but little direct relation to the public health. The popular notion, as we understand it, is quite to the contrary, and that notion it was that we were combating in our issue of Nov. 5. We did not for a moment mean to say or imply that garbage disposal works should be located, constructed, or operated without regard to the personal comfort or to the effect on real estate values of any section of a community. We did mean, and we still believe, that both lay and medical writers have condemned garbage disposal plants, and particularly reduction works, by direct or implied assertions that they were serious menaces to the public health.

Assuming, as our correspondent now does, that garbage disposal works are liable to be offensive rather than dangerous, and that in choosing between reduction and cremation comparative economy may take precedence of the comparative liability to offense, what are the data on which to base conclusions? We still believe that they are insufficient to warrant the assertion that cremation is probably cheaper and certainly less offensive than reduction. The opinions as to offensive odors are of doubtful scientific value. And, most important of all, there is practically no evidence as to what could be accomplished by either cremation or reduction, under American conditions, if a city should attack the problem as most cities do other engineering problems. To our minds, the unsatisfactory condition of garbage disposal in the United States is not due to the fact that our large cities have almost invariably chosen reduction instead of cremation, nor to the fact that where cremation has been employed we have seldom adopted the British plan of mixing ashes with the garbage. Our trouble lies in the failure of American cities to consider garbage disposal as an engineering problem and to entrust its solution to engineers. We willingly admit that much that Americans have done in the way of garbage reduction is bad, but we assert that the same is true of cremation, and that the latter would be far more apparent were not the cremation plants mostly located in small cities. These opinions are based largely upon personal ispection of both reduction and cremation plants, and are supported by detailed accounts, in our possession, of controversies over both reduction works and crematories scattered from Massachusetts to California and from Minnesota to Texas.

Finally, we consider the complaints against the Boston garbage reduction works notable illustrations of the baneful effects of treating garbage disposal as a matter of politics, prejudice and sentiment rather than one of business and engineering. The garbage question in Boston has been a sort of political foot ball, brought out, like other foot balls, well along in the fall of the year, but put away at about election time, instead of after Thanksgiving. Doubtless some have participated in the game without realizing it, but the spectacle has been none the less interesting to observers. —Ed.)

Notes and Queries.

"Contractor" is informed that we cannot answer anonymous inquiries.

The engine of the Sullivan Machinery Co.'s four-stage air compressor was stated in the article in our issue of Nov. 26 as being of 21 HP. This should have been 210 HP., as will readily be seen from the description of the size of the machine.

As a further contribution to the discussion on the heat treatment of steel, carled on in our columns some weeks ago, Mr. A. A. Stevenson, Superintendent of the Standard Steel Works, at Burnham, Pa., writes us as follows:

A number of years ago we had some trouble with tires for foreign service which were subjected to drop test. We found upon experiment that the ability to stand a drop test depended, more than anything else, upon the finishing temperature at which the tire was rolled.

MEASUREMENTS OF RELATIVE HUMIDITY IN OFFICES AND DWELLING HOUSES IN WINTER.*

By G. A. Loveland.†

The previously evident effect of dry air on the furniture in the United States Weather Bureau office in Lincoln, Neb., during the winter months resulted in the taking of a few observations to determine the relative humidity of the air in the rooms in the winter of 1898-99. The relative humidity proved to be so low that it was decided to make a consecutive record for the next winter, that of 1899-1900. Mr. A. B. Smith, a student in the university, working in the office, becoming interested, kept the record. Observations were made usually twice a day, but sometimes as many as four or five times a day, and occasionally but once a day. The observations were made by means of an ordinary sling psychrometer.

The rooms are heated by steam, using the ordinary pipe radiators. Lack of time prevented Mr. Smith's computing the relative humidity from the mass of observations for the use he intended to make of them. When he graduated in June, 1901, he transferred his data to me in the hope that it might prove useful. During the summer and early fall these observations were computed and tabulated for convenient study by my wife and myself. The result proved that the air in the office was exceedingly dry during the whole winter. The coldest month, February, 1900, with a mean temperature in the shelter of 19.2° above zero, was also the driest in the office, with an average relative humidity of but 15.3%. The variation was not great from day to day, the extreme ranges for February, 1900, being from 7 to 25%; but the record shows that it was only twice above 20% and once below 10%. December, 1899, comes next, with a mean exterior air temperature of 22.6° and a relative humidity in the office of 18.6%. January, 1900, was warmest and in the office the most moist, with a mean temperature of 26.8% outside, a relative humidity of 21.0° inside. The temperature of the office did not vary materially for the three months, and averaged slightly below 70°. The relative humidity, from the readings of the whirled psychrometer in the shelter, was: For December, 77.4; for January, 73.4, and for February, 77.9%. This gives a mean relative humidity of the outside air for the three months of 76.2%, while for the inside air for the same period it was but 18.3%. In an article in the "Boston Medical and Surgical Journal" of March 1, 1900, Mr. R. DeC. Ward, Instructor in Climatology in Harvard University, gives the relative humidity of the outside air at many of the driest places where observations have been kept, including places near the deserts in both Asia and Africa, but he quotes no place as dry as the Weather Bureau office at Lincoln was during the three months mentioned.

The results obtained as above stated caused me to attempt an experiment this winter. I live in the north half of a double house. The two halves are very much alike, of course being built under exactly the same conditions, and heated by the same sized furnaces of the same make and pattern. The arrangement of rooms is slightly different, but the cubic space of each house is about the same—14,000 cu. ft. Furnaces are almost invariably furnished with a pan in which water may be kept, since, as text-books say, "heated air requires more moisture than cold air contains to maintain a comfortable degree of saturation."

The investigation began by using the water pan in my furnace and not using the one in my neighbor's house, and by making humidity observations to determine the efficiency of the pan as an attachment to a furnace. The water pan holds 20 quarts. The amount of water evaporated from the pan was determined each day by filling it daily and measuring the water required. The observations commenced Nov. 4 and were taken once daily by my wife about 12.00 noon. The result of the first 17 days' observations was as follows:

	Average Temperature of air.	Average Relative humidity.
Inside, with water pan.....	72.1°F.	56.2%
Inside, without water pan.....	67.9°F.	38.8%
Outside	39.4°F.	68.2%

The amount of water evaporated was two quarts per day. The difference in humidity seems to be due almost entirely to the fact that one house was, on the average, warmer than the other. Reduced to a temperature of 70°, there seemed to be a slight difference—about 1%—in favor of the house with the water pan, but the difference was so very slight that the value of a water pan as an adjunct to a furnace was not established, but on the contrary it seems probable that such a small pan is of little or no value.

It was then determined to increase the evaporation sufficiently to affect the humidity, continuing to measure the water. Pans of water were placed in each of four registers. This increased the evaporation to an average of 5.9 quarts per day for the 17 days beginning Nov. 23. The averages for this period were as follows:

	Average Temperature of air.	Average Relative humidity.
Inside, with water pan.....	70.0°F.	35.8%
Inside, without water pan.....	70.0°F.	33.4%
Outside	39.3°F.	73.8%

For this period the temperatures in the house averaged the same and the relative humidity was 2.4% greater in the house using water in the furnace and register pans.

Two large pans were now attached to the furnace at the point where the cold-air return delivers the air to the furnace to be reheated. These were in operation for the period from Jan. 15 to Jan. 21 and increased the evaporation to 10 quarts per day for the period, with the following results:

	Average Temperature of air.	Average Relative humidity.
Inside, with water pan.....	69.9°F.	29.1%
Inside, without water pan.....	70.0°F.	26.9%
Outside	33.3°F.	66.8%

This shows a difference of 2.2% in favor of the house in which the 10 quarts of water were evaporated daily, from which it would seem that the 4.1 quarts increase in water evaporated did not quite offset the lower temperature (averaging 6°) and lower humidity (averaging 7%) of the outside air in the second experiment.

The only ventilation the houses have is one open fireplace in each. No special effort was made to change the air other than that resulting from the ordinary usage of dwelling houses. As the two houses were so nearly identical in all conditions affecting ventilation, it was assumed that the change in air was practically the same in both houses. Neither furnace took air directly from outdoors; the cold-air return from the rooms and air from the cellar were the only sources of air for the furnaces. If there was no change in the air, six quarts of water would be sufficient to saturate the air in one house. It seems probable, however, that the air in a house of this kind, with no special effort at ventilation, changes completely once in two hours, and possibly once an hour, or even in less time. With this in mind, it will be seen that in a house of the kind in which these experiments were made (ordinary 8-room), 70 to 150 quarts of water, or possibly more, per day, will be required to maintain the relative humidity as high as it is outside the house, the difference between inside and outside temperatures being from 35° to 50°, as is the case in winter months in Nebraska. This degree of humidity would not be desirable, for the moisture in the house would condense on the windows to such an extent as to be very disagreeable. In fact, later in the winter, with a daily evaporation of 36 quarts and a temperature slightly above zero outside, 70° inside, and an inside relative humidity of 30% (about 10% higher than in a house without evaporation), considerable condensation on the windows took place, but not sufficient to be troublesome.

At present, from a rather short series of observations in a house heated by hot water, but quite extensive observations in furnace and steam heated rooms, there seems to be litt'e or no difference, so far as the relative humidity of the air is concerned.

I do not know what effect the dry air of living and office rooms has upon health, being unable to find a record of any experiments in this direction. Most physicians mainta'n that it is injurious, but this seems to be based mainly upon theoretical considerations.

*A paper read before the Nebraska Academy of Sciences, January 25, 1902.

†Section-Director, U. S. Weather Bureau, Lincoln, Neb.

THE SUPERSTRUCTURE FOR THE MANHATTAN BRIDGE ACROSS THE EAST RIVER AT NEW YORK CITY.

(With two-page plate.)

Few bridges designed in recent years have received such extended discussion by prominent engineers as has the proposed new chain cable suspension bridge across the East River at New York city. As this discussion has been based almost wholly on only a very general knowledge

of the exact details, engineers are, we feel certain, desirous of examining for themselves the actual construction which is called for by the designers of the bridge. This has been made known in its entirety only within the past week by the issue of the final contract plans and specifications.

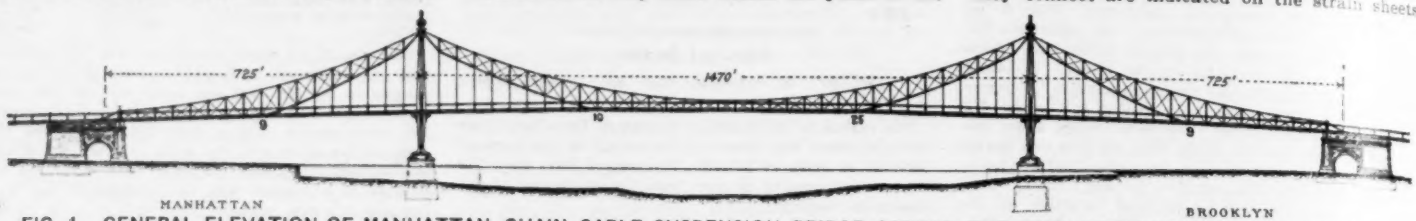


FIG. 1. GENERAL ELEVATION OF MANHATTAN CHAIN CABLE SUSPENSION BRIDGE ACROSS THE EAST RIVER AT NEW YORK CITY.

The drawings are so extensive that only the essential structural features can be reproduced here. These are sufficient, however, to give a very fair knowledge of the proposed structure if they are studied in connection with the discussion referred to above, and with the architectural views published in Engineering News of Feb. 10, 1903.

GENERAL DESCRIPTION.

The new Manhattan Bridge is shown in diagram elevation by Fig. 1. It is a stiffened chain cable suspension bridge, with three spans. The cables are four in number and are spaced transversely of the bridge 28 ft., 40 ft., and 28 ft. apart c. to c. Each cable consists of eye-bars linked together by pins. The cables are hinged at each anchorage to the anchor chains and at each side of both towers to connecting links at the tower tops. The towers each consist of four legs set in the same plane up and down stream, and thoroughly braced together, as shown by the diagram elevation, Fig. 2. Each tower leg is hinged at the bottom so as to be free to oscillate in the direction of the axis of the bridge. The length of each shore span between the tower centers and the anchorage connections of the shore cables is 725 ft., and the length of the main span between centers of towers is 1,470 ft. The shore spans are each divided into 17 panels and the center span has 35 panels.

The bridge has no stiffening trusses in the sense that this term is applied to the suspended trusses of the Brooklyn and Williamsburg wire cable suspension bridges, but the same end is secured in another manner. This may be explained by reference to the diagram, Fig. 1. Considering the main span, it will be observed that the cable chains are connected by struts and diagonals to stiffening chords. These stiffening chords extend from tower to tower and are in the plane of the floor system and connected to it between panel points 10 and 25. Sections of these stiffening chords where they come within the plane of the floor system are shown by the cross-section, Fig. 3. The web struts are stiff members and the diagonals are adjustable eye-bars. The shore span cables are stiffened in exactly the same manner as the main span cables.

Between the points where the stiffening chords leave the floor plane and the adjacent towers, the floor is carried by suspenders connecting with wind chords in the floor plane. The composition of these suspenders and of the chords to which they connect are indicated on the strain sheets. These sheets require some little study to be understood, but they give practically all the details there are available of the cables and their stiffening and suspender systems for the two portions of the bridge between panel points 9 and 10 and

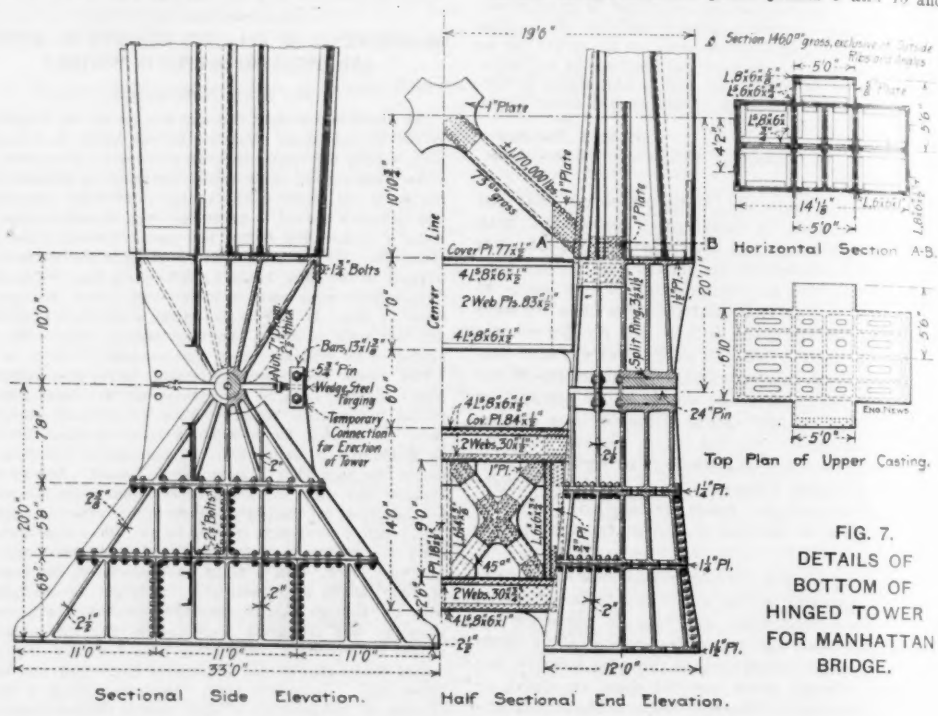


FIG. 7. DETAILS OF BOTTOM OF HINGED TOWER FOR MANHATTAN BRIDGE.

TABLE II.—PHYSICAL REQUIREMENTS FOR STEELS FOR MANHATTAN BRIDGE AS SHOWN BY SPECIMEN TESTS.

	Ultimate Tensile Strength.	Elastic Limit.	Elongation.		Reduction of Area.	Character of Fracture.	Cold Bend Without Fracture.	
	lbs. per sq. in.	lbs. per sq. in.	Min. % in 8 ins.	Min. % in 2 ins.	%		Material less than 1 in. thick.	Material 1 in. or more thick.
Nickel Steel.								
Eye-bars (unannealed)	100,000 min.	55,000 min.	1,600,000 / Ultimate Tensile.	..	To be recorded.	Mostly silky and free from coarse crystals.	180° around a pin with diameter = 3t.*	
Eye-bars (annealed)	85,000 min.	48,000 min.	1,600,000 / Ultimate Tensile.	..		" " "	Pieces of bar not less than 4" wide. 180° around pin with diameter = 2t.	
Pins (unannealed)	90,000 min.	50,000 min.	..	20		" " "	180° around pin with diameter = 3t.	
Plates and Shapes	"	"	1,600,000 / Ultimate Tensile.	..		" " "	"	
Structural Steel.								
Plates, Shapes and Bars for riveted work	60,000 desired	30,000 min.	1,500,000 / Ultimate Tensile.	..	..	Silky.	180° Flat.	180° around pin with diameter = 2t.
Eye-bars and Pins	66,000 desired	½ of ultimate	" "	22	..	"	"	"
Rivet Steel	50,000 desired	½ of ultimate.	" "	..	..	"	180° Flat.	
Rivet Steel, nicked and bent around bar of same diameter as rivet rod.	.....	.....	.....	..	..	Fine, silky, gradual break —uniform fracture.		
Steel Castings (annealed)	65,000 min.	½ of ultimate.	.....	18	..	Silky or fine granular.	90° around pin with diameter = 3t.	

*t is the thickness of the specimen.

TABLE III.—PHYSICAL REQUIREMENTS FOR STEELS FOR MANHATTAN BRIDGE AS SHOWN BY FULL-SIZE TESTS.

	Ultimate Tensile Strength.	Elastic Limit.	Elongation.	Reduction of Area.	Character of Fracture.	Cold Bend Without Fracture.
	Pounds per sq. inch.	Pounds per sq. inch.		%		
Nickel Steel.						
Eye-bars	.....	.....	.....	To be recorded.	.....	180° around pin with diameter = 3t.*
Eye-bars (annealed)	85,000 min.	48,000 min.	9% in 18 ft, including fracture.		Mostly silky and free from coarse crystals.	In the neck of the bar, 90° around pin with diameter = 2¼t.
Structural Steel.						
Eye-bars and plates	.....	.....	.....	.....	.....	180° around pin with diameter = 2t.
Eye-bars (annealed)	56,000 min.	½ of Ultimate.	10% in body of bar.	.....	Fine, silky.	
Angles ¾ in. or less in thickness	.....	.....	.....	.....	.....	Open flat, under blows of hammer.
Angles ½ in. or less in thickness	.....	.....	.....	.....	.....	Bent shut under blows of hammer.

*t is the thickness of the piece.

TABLE IV.—Showing Allowable Strains in Calculating Manhattan Bridge.

	For Dead Load Temperature and Regular Live Load, or For Dead Load, Temperature and Wind.	For Dead Load, Temperature and Congested Live Load, or For Dead Load, Regular Live Load, Temperature and Wind
	Pounds per Square Inch.	
(a) For Nickel Steel—		
Tension in chains	30,000	39,000
" stiffening trusses	.....	40,000
Compression in stiffening trusses	.....	40,000-150-* l/r
Shear on pins	20,000	24,000
Bearing on diameter of pins	40,000	48,000
Bending on outer fibre of pins	40,000	48,000
(b) For Structural Steel in Trusses, Towers and Bracing—		
Tension	20,000	24,000
Compression	20,000-90-* l/r	24,000-100-* l/r
Shear on shop rivets, bolts and pins	13,000	16,000
Bearing on diameter of shop rivets, bolts and pins	25,000	30,000
Bending on outer fibre of pins	25,000	30,000
	Pounds per Square Inch.	
(c) For Structural Steel in Hangers—		
Tension	18,000	
Shear on shop rivets, bolts and pins	12,000	
Bearing on diameter of shop rivets, bolts and pins	24,000	
(d) For Structural Steel in Floor System of Roadway and Footways—		
Tension chords	15,000	
Shear on shop rivets, bolts and web-plate net sections	10,000	
Bearing on shop rivets and bolts	20,000	
(e) For Structural Steel in Floor System for Railroad and Trolley Tracks—		
Tension chords	10,000	
Shear on shop rivets, bolts and web-plate net sections	7,000	
Bearing on shop rivets and bolts	14,000	

*Where l = length and r = least radius of gyration both in inches.

panel points 9 and 25. For the remaining portions, Fig. 3 shows the cables, the stiffening chords and the posts between them, together with the connection of these members to the floor systems. It will be noted that the roadway has a buckle-plate floor which forms the lateral system in that plane, and also that the main floor beams are hinged at points about under the two inside cables. The other details of the cross-section are made sufficiently clear by the drawings.

SPECIAL DETAILS.

In the preceding description the individual details were only briefly touched so as not to cause confusion in understanding the main structure. Many of these details are, however, decidedly unusual. Unfortunately, some of the most interesting are only indicated in the contract drawings and specifications, their full design being left to the contractor to develop. These cannot, of course, be given, but others which have been worked out in detail are available for illustration and are given in the accompanying drawings.

LOADS.—The loads for which the bridge is required to be calculated include, in addition to its own weight, the following live loads: For the chains, trusses and towers; (a) a load of 8,000 lbs. per lin. ft. of bridge as "regular," or (b), 16,000 lbs. per lin. ft. of bridge as "congested" traffic. For the hangers, floor beams and floor system; (c) on each elevated track a load of 52 tons on four axles 6 ft. × 10 ft. × 6 ft. apart; (d) on each street-car track either a load of 26 tons on two axles 10 ft. apart or a load of 1,800 lbs. per lin. ft .of track; (e) on any part of the roadway a load of 24 tons on two axles 10 ft. apart and 5-ft. gage (assumed to occupy a width of 12 ft. and a length of 30 ft.), and upon the remaining portion of the floor a load of 100 lbs. per sq. ft.; (f) on the footwalks a load of 100 lbs. per sq. ft.

In this connection it should be explained that the strains shown on the sheets reproduced on our inset are for a dead load of 31,000 lbs. and a live load of 8,000 lbs. per lin. ft. of bridge (4 trusses). The congested load strains of course run higher; for example, the resultant strain in the tower link of the main span cable is 19,337,000 lbs. under congested load. The wind pressure in all calculations was assumed as a moving load acting in either direction horizontally with a force of 2,000 lbs. per lin. ft.

TOWER LEGS.—The tower legs are wrought steel structures of varying lateral dimensions from bottom to top, as indicated by the diagram plans of Fig. 2. The net section of each leg decreases from 1,460 sq. ins. at the bottom to 912 sq. ins. at the smallest section. Each leg has attached to its bottom a pin casting and carries on top the links which connect the shore span and main span cables. All the main dimensions are given on the drawings of Fig. 2, and it is interesting to speculate upon the sizes of some of the pieces which will have to be handled in erection and transportation. The bracing between tower legs is indicated sufficiently by the diagrams.

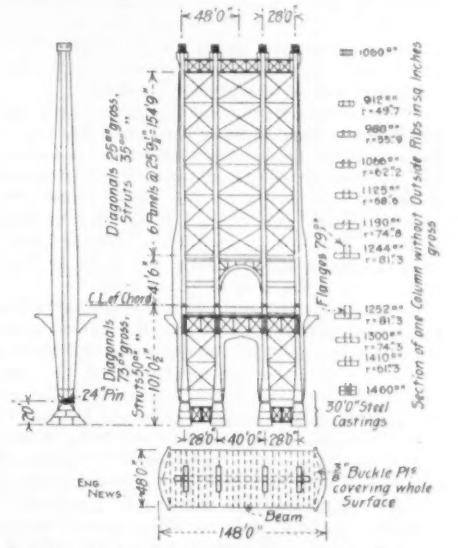


Fig. 2. Diagram Elevations of Hinged Towers for Manhattan Bridge.

TOWER HINGES.—The hinge construction at each tower leg, by means of which the tower is free to oscillate with the expansion and contraction of the cables, is shown in detail by Fig. 7. It consists (a) of a pyramidal pedestal casting in three parts bolted together, the topmost of which is grooved to receive a 24-in. pin; (b) of the hinge pin 2 ft. in diameter and 8⅓ ft. long, and (c) of the shoe casting of the tower leg which is grooved on the bottom to set over the hinge pin. The pedestal castings are braced apart by a heavy lattice girder and a plate girder in the same vertical plane connects the shoe castings. The dimensions of these steel castings are given on the drawings and merely require mention here.

The temporary connection for the erection of the tower deserves notice. It is required by the specifications that the tower shall be self-supporting during erection. These temporary connections are designed to make this requirement possible. They consist, as will be seen, of a sort of fish-plate link clasping the fins of the pedestal and shoe casting across the interval between them, which is allowed for the rocking motion of the tower, and of an adjustable wedge between the adjacent edges of the fins.

CABLE CONNECTIONS AT TOWERS.—The drawings of Fig. 8 show the details of the top sections of the tower legs. Each is capped by 1½-in. plate milled to a true plane on top. On this 19 plates 1 11-16 ins. thick are set on edge parallel with the bridge axis, so as to pack between the eye-bars of the cables and the connecting bars of the cable stiffening chord. The plates are bound together by the 16-in. cable pins and by 3½-in. bolts and spacers. Hook bars riveted to the ends of the plates keep them from sliding on the bearing plate. The other details are sufficiently indicated by the drawings.

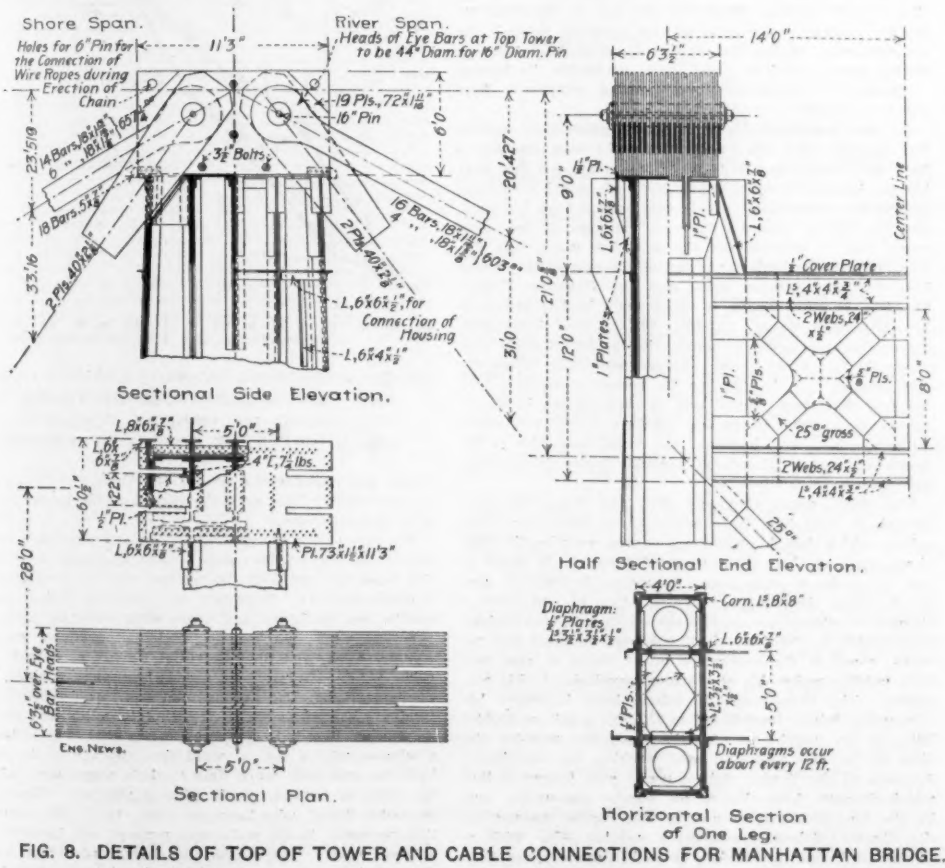


FIG. 8. DETAILS OF TOP OF TOWER AND CABLE CONNECTIONS FOR MANHATTAN BRIDGE.

ANCHORAGES.—The anchorages are of concrete faced with granite, and each one is 218 ft. long and 182 ft. wide. The drawings of Fig. 6 indicate only the lower part of the anchorage masonry. The trough-shaped recess in the forward part extends clear through the anchorage and gives passage to a city street. This passage is arched over and above it the anchorage is hollow and contains an assembly hall 71 × 128 ft., with ample corridors, coat rooms, etc., on each side. Referring to Fig. 6, it will be seen that the concrete at the bottom of the anchorage is reinforced by seven layers of 12 × 12-in. timbers extending clear across the foundation transversely. It is also reinforced under the street arch by 1-in. steel rods. A similar reinforcement is introduced over the tops of the anchor chambers.

The anchors and anchor chains are fully shown by the drawings of Fig. 6 and call for but little further explanation. No details are here given of the vertical strut, which takes the vertical component of the strain at the outer ends of the anchor chains and carries it to the anchorage masonry forward of the street opening, but the construction is substantially the same as that of the shorter inclined strut at the rear.

CABLE CHAINS.—No details of the cable chains are given by the contract drawing except such as may be determined by the drawings of Figs. 3 and 8 and as may be interpreted from the strain sheets. The eye-bars are, however, 18 ins. wide and vary from 1⅛ ins. to 2 ins. in thickness. They have heads 38 ins. in diameter and 16-in. pinholes.

MATERIALS.—The specifications state that nickel steel may be used for the eye-bars and pins of the cables and for the lower chords of the stiffening trusses. For all other parts structural steel shall be used unless otherwise ordered or approved by the Commissioner of Bridges. All steel is to be made by the open-hearth process and

TABLE I.—Chemical Requirements for Steel for Manhattan Bridge.

	Phosphorus % Max. Basic.	Phosphorus % Max. Acid.	Sulphur % Max.	Nickel % Min.
Nickel Steel:				
Eye-bars, pins, plates, shapes	.04	.06	.05	3.25
Structural Steel:				
Plates, shapes, bars, pins...	.04	.08	.05	....
Rivet steel	.04	.04	.04	....
Steel castings.....	.05	.08	.05	....

is to fill the requirements shown by Table I. for chemical composition, and by Tables II. and III. for physical strength, etc. It is required that all steelwork shall be so proportioned that the maximum strains from dead load, temperature and live load, or for dead load, temperature and wind, shall not cause greater unit strains than those indicated in Table IV.

The specifications for tests, construction and painting are practically identical with those for the Blackwell's Island Bridge, which were published in Engineering News of Sept. 3, 1903. The specifications for erection are brief and general in character. It is stated that the towers must be so erected as to be self-supporting and that the cables "shall be erected from a temporary suspension bridge of suitable design and capacity to secure safe and speedy erection, and all operations shall be conducted so as not to obstruct navigation."

The bridge was designed by the engineering staff of the Department of Bridges under the direction of Mr. Gustav Lindenthal, M. Am. Soc. C. E., Commissioner of Bridges of New York city.

THE MONEY VALUE OF TECHNICAL TRAINING.*

By James M. Dodge,† M. Am. Soc. M. E.

Technical Training may be self-acquired or obtained through instruction. The ability to drive a nail properly, or to design and construct the most complex and wonderful of structures or devices, is the result of Technical Training in but different degree. Up to a very recent date, and within the memory of most of us, the Apprentice System and that of Independent Delving represented the sole methods of acquiring training. Research and investigation carried on in individual lines, with varying degrees of success, dependent upon the mental makeup of the individual, were the means of attaining theoretical technical knowledge. The blending of these two methods developed the earlier Mechanical Engineers and will, even in the future, enable those sufficiently gifted by nature and habit to attain eminence. The progress of the world, however, calls for a better and more speedy means of producing trained men than could ever be developed by the methods of self-instruction. A generation or so ago, the universal belief was that the sooner a young man entered upon his apprenticeship, or began practical manual work, the better and more rapid would be his progress in the Mechanic Arts, and Book Learning was derided as being purely theoretical, and of little practical value. This belief is, even at this date, all too prevalent, largely due to inherited error, and to lack of knowledge and reliable data.

Obtaining data from which incontrovertible conclusions can be drawn is now comparatively easy, but a few years ago was practically impossible. We are all prone to take extreme cases of success or failure as the basis of our opinions, and lose sight of the fact that it is the average man whose career shows the true force and direction of the current. For convenience of comparison, I will outline the actual progress made by four groups of men working in the Mechanic Arts. Each group I will refer to as an individual:

The first, the Laborer, with but primitive and rudimentary training, working under the immediate and constant supervision of a boss, and earning, as the line on the chart indicates, $10.20 per week at the age of 22, his line remaining horizontal through the period of his usefulness. Data are lacking as to his progress before he reaches the age of 22.

The second, the Apprentice or Representative of the Shop-trained group, of good health and habits, entering a machine shop at the age of 16, and earning an average wage of $3 per week for 50 weeks per year, which is about the number actually worked, is $150, or 5 per cent. on $3,000. This, then, is his Potential or Invested Value, upon which he draws his interest on pay days.

On the accompanying diagram the horizontal lines represent amounts increasing from the lower line upward by $1,000 each; starting at $1,000, and terminating at the top at $50,000. These represent "potential values," upon which 5% is earned for 50 weeks a year. The vertical lines each represent one year in time, beginning at the lower left hand corner at 16, and progressing in regular order until, at the lower right hand corner, we have 32, representing in all a lapse of 16 years.

To illustrate the progress of the four groups graphically, we indicate on the line representing 16 years of age, and opposite the figure $3,000, the young man just entering his apprenticeship. We will consider him typical of the Shop-trained Group. Following the line to the right we see his average progress in earning capacity through the ensuing years, noting that at the age of 20 he is earning $9 per week, which is 5 per cent. on $9,000, he having increased his "potential" or "invested value" in four years by $6,000.

We now note that his accumulated experience enables him to make more rapid progress for the next year and a half, and from the age of 20 to 21½ years we find that his pay has increased to $13.20 per week, and his "Potential Value" to $13,200. He is now approaching his goal, and his line of progress does not continue at the same angle that it followed for the past few years, but deflects toward the horizontal; and at the age of 24 we find him earning $15.80 per week, and his "Potential Value" $15,800. In other words, in eight years he has increased his "Potential Value" $12,800. Observation shows that 5% of the apprentices acquiring the machinist trade rise above the line made by our average man; 35% follow the line closely, and that during the period of training 20% leave of their own accord, and as near as can be ascertained go to other shops and continue in the line originally selected; 40%, however, are found unworthy or incompetent, and are dismissed, probably never rising to the $15.80 line.

The third group of young men are those fortunate enough to have had the opportunity of entering a trade school, which they do at 16 years of age, devoting the next three years of their lives, or until they are 19 years of age, acquiring a trade under competent instruction, and at the same time adding to their store of rudimentary theoretical education. At the age of 19 a Trades' School man enters the machine shop and can command $12 per week, equal to the apprentice of 21 years of age, and very quickly makes his employment profitable to his employer. The three years in school have increased his "Potential Value" from $3,000 to $12,000, a gain of $9,000. Thus he has caught up with the apprentice entering the shop at 16, and who has been working for five years. Progress of the Trades' School group now follows a line which diverges from that of the regular apprentice, and by the time $15.80 is earned by the regular apprentice, the Trades' School graduate is earning $20, with a "Potential Value" of $20,000, or $4,200 greater than that of the shop-trained man. The Trades' School line continues at substantially the same angle up to an earning capacity of $22 per week, and a "Potential Value" of $22,000. Data are lacking as to the further progress, but the presumption is that this line will bear off more toward the horizontal, eventually paralleling the line of the Shop-trained man, but much higher on the chart.

The fourth group we will represent again by a boy of 16 studying at school until his 18th year, and preparing himself for admission to one of our higher technical institutions, such as the Stevens Institute, the Massachusetts Institute of Technology, Columbia, Cornell and the like, where, after a four years' course, or at the age of 22, he is ready to begin practical work. The statistics upon which this chart is based show the average starting wages at $13 per week, or the same amount earned by the regular apprentice at the age of 21½, and by the Trades' School graduate at the age of 19½. In other words, apparently a graduate of our technical schools has lost by his six years of preparatory study, having been beaten by the regular apprentice by six months and by the Trades' School graduate by 2½ years. From this time, however, there develops a most interesting and instructive line of progress. The regular apprentice, who is earning $13.50 a week at the time the technical graduate is earning $13, is overtaken in six months, and we find both earning $14 per week, and the technical graduate reaches the $15.80 line nearly one year before the regular apprentice. In other words, while it has taken the regular apprentice from his 21st to his 24th year, or three years, to increase his wages from $11.50 to $15.80 a week, the technical graduate has done the same in fifteen months.

Progress now continues on substantially the same line, and we find the technical graduate earning $22 per

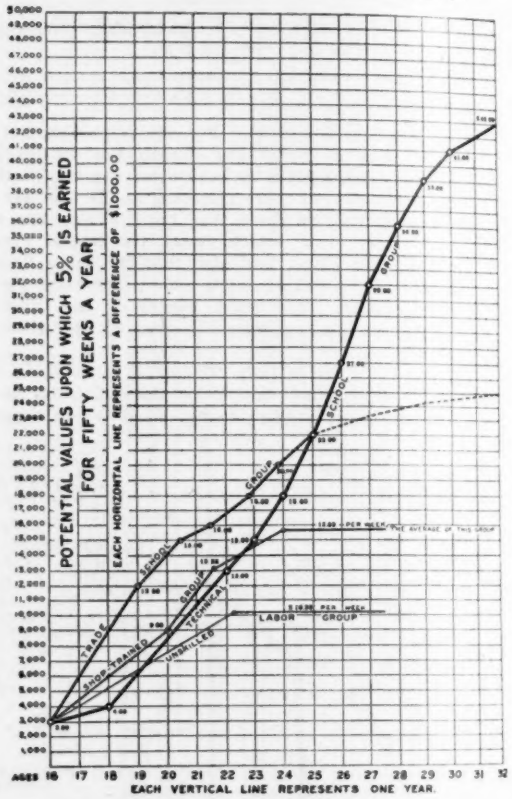

POTENTIAL VALUES UPON WHICH 5% IS EARNED FOR FIFTY WEEKS A YEAR
EACH HORIZONTAL LINE REPRESENTS A DIFFERENCE OF $1000.00
SCHOOL GROUP
TRADE
SHOP-TRAINED
TECHNICAL
UNSKILLED
LABOR GROUP
AGES 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
EACH VERTICAL LINE REPRESENTS ONE YEAR.

DIAGRAM SHOWING AVERAGE EARNING POWER AND CAPITALIZED VALUE OF YOUNG MEN FOLLOWING MECHANICAL PURSUITS AND GIVEN DIFFERENT GRADES OF TRAINING.

week, and crossing the line of the Trades' School group in three years' time, a worthy tribute to the higher education and attainment.

The line of the technical graduate now continues divergent from that of the trades' school graduate, with earning capacity regularly increasing, and a corresponding augmentation of "Potential" or "Invested Value" until, at the age of 32, or ten years after entering upon the practical work, we find our technical graduate earning $43 per week, and his "Potential Value" at $43,000. In other words, six years of preparation have enabled him to distance the Shop-trained man and the Trades' School graduate overwhelmingly. Bearing in mind that this is an average line, it is of interest to say that most technical graduates with a better record than the one in the chart have devoted even more time to their preparation, either by study or by shop work, after graduation. Those, on the other hand, who have not come up to this average line represent, in the main, men more or less incapable of original work. The reason that higher education, other things being equal, carries with it the ability to earn high wages is that consciously or unconsciously, these men are directing and making it possible for large numbers of laborers, shop-trained men and trades' school graduates to perform useful work. A draftsman at his board may never realize that as a result of his drawing a hundred men or more may be given employment. His design calling for structural steel, for instance, could not be built were it not for the labor of many men employed making and rolling the steel before it reaches the shop.

*Presidential address before the American Society of Mechanical Engineeers.

†President Link-Belt Engineering Co., Nicetown, Philadelphia, Pa.

Then come the shop men, who cut, punch and shear, and then the erectors, who assemble the structure in accordance with the original plan. For this ability and knowledge our technical man is paid.

It is quite obvious that all workers in the mechanic arts cannot be technical graduates. Some must, through natural limitations, or lack of opportunity, follow the apprentice line, and others the trade school. It is from graduates of the latter that leading shop men and foremen are largely selected. These two classes, supplemented by the technical graduate, constitute the vast army of workers in the mechanic arts.

Thus we see clearly that preparation pays, and that it pays in dollars and cents, and that even a long term of years spent in proper study and technical training is a good investment from every point of view.

Of course, apprentices have made and will make, in rare instances, a better showing than the average technical man of the chart, and many of our greatest men have, by sheer force of character, excellence of brain fiber, persistence and self-education, risen to preëminent positions, independent of all regular systems. To the end of time great examples of this kind will be found. Among those whose names readily come to mind are the elder Krupp, Joseph Whitworth, George M. Pullman, Andrew Carnegie, John Fritz, Prof. John E. Sweet, Edwin Reynolds, George H. Babcock and Coleman Sellers.

The same is true of the Trades' School graduate, but as said before, we are dealing with the average of each class, taken from actual statistics, with an earnest desire to ascertain the facts, and without any preconceived notion of the outcome.

It may be stated as a truism that every man pays for the amount or percentage of bossing he requires, and conversely, every man's wages increase in proportion to his ability to act as the boss or foreman of himself and others. The lower the wage rate the greater the amount of watching and directing constantly required. The slaves of ancient Egypt received no wages, but were treated as horses are to-day. They were fed and sheltered according to the ideas of their owners. No slave worked voluntarily, and the foreman's or leader's excellence was gaged entirely by his physical strength and efficiency as a driver. This was certainly the zero of labor conditions.

The highest wages are paid to the man through whose ability the largest number of other men may be most profitably employed. He does his work with his brain. Thus, on the one hand, we see manual labor receiving no wages, and on the other mental labor reaping the highest reward. Between these two extremes is found every condition of human life.

The technical training of an individual makes him valuable just in proportion as his ability is manifested by good judgment and perception. Trained common sense receives the highest compensation and reaps the greatest reward.

The most interesting of all graphical charts would be that properly exploiting the value of technical training to manufacturing plants and enterprises. To illustrate this more clearly, we may fairly assume that the apprentice of our chart corresponds to the old-fashioned primitive shop, having practically no overhead expense, the proprietor carrying the business "in his hat," priding himself on his non-receptive sturdiness, contempt for improvements and personal attention to all details. For his costs he adds together the value of raw materials and labor, and then adds a few dollars for profit. The line of this establishment would parallel the $15.80 line of our Shop-trained group.

The Trades' School line on the chart truthfully represents establishments in which some attention has been paid to the improvement of system, with an increased so-called non-productive force, operating possibly in some particulars with brilliancy, but with defective features in others; acknowledging the value of improvement if internally originated; moderately but unconsciously absorbent of ideas from without, but tenacious of dogma and lacking departmental symmetry. Growth, increased earnings and relative immunity from disastrous failure result.

The technical graduate line of our chart represents the manufacturing establishment technically trained and "abreast of the times" in all particulars, and I predict a time not very far distant when it will be almost universally recognized that establishments should be trained as well as individuals, and that the marvellous development in scientific shop practice and management will do for the manufacturer fully as much as technical training is doing for the individual.

It may be truly said that this Society, and others allied in promoting the Mechanic Arts, complete the system of technical training by going beyond the province of the technical schools, their students being the men who constitute the management of our manufacturing enterprises.

APPARATUS AND METHODS FOR TESTING AIR MOTORS AND AIR HAMMERS.*

By M. H. Wickhorst,† Jun. Am. Soc. M. E.

The apparatus and methods described below are those used in some extensive tests of air-drill motors and air hammers made by the Chicago, Burlington & Quincy R. R. Co. in its laboratory at Aurora, Ill. The tests were made for the purpose of determining the air consumption, horse-power, stalling load of motors, number and force of hammer blows, etc.

GENERAL ARRANGEMENT.

The general arrangement of the apparatus is shown in Fig. 1.

The air used for making the tests was obtained from the shop supply, which was generally about 60 or 70 lbs. As we desired pressures varying from 60 to 120 lbs., we stepped up the pressures by pumping the air through a 9-in. Westinghouse pump which had the air cylinder bushed to a diameter of 7 ins. This bushing was necessary as the steam pressure at the laboratory is only about 60 lbs. The air was then pumped into reservoir No. 1, with ordinarily a pressure of 140 or 150 lbs. From here the air was allowed to flow into reservoir No. 2, where it was maintained at any pressure desired by means of a reducing valve, which was a regular 1-in. Westinghouse air-pump governor. An oil cup containing a thermometer was screwed into reservoir No. 2, and was used to determine the temperature of the air supplied to the tool. Another thermometer was also used to note room temperature.

From the reservoir No. 2 the air passed through a meter. This is a high-pressure meter made by the Equitable Meter Co., Pittsburg, Pa., and in construction is similar to an ordinary gas meter, the air alternately filling out and exhausting from leather bellows. From here the air was delivered to the tool to be tested, through a 2-in. pipe and 1¼-in. hose. At the point where the air was delivered to the tool we had an expansion consisting of a 2-in. tee, with an internal diameter of about 2¼ ins., in which we determined the pressure by means of a gage. Care was taken that between the point where the pressure readings were taken and the tool to be tested, there was no contraction in the supply pipe smaller than the opening into the tool under test.

For the purpose of calibrating the air meter we used the tank as shown in Fig. 1. This tank had a gage glass its full length, and its cubic capacity was determined for each 5 ins. on the glass by weighing the water.

The records of time, revolutions of motor, air consumed and strokes of hammer were obtained autographically, using the record table shown in Fig. 1. The records were obtained on glazed manilla paper 14 ins. wide, moving across the table under electro-magnetic pens. The driving mechanism of the paper consisted of an air motor and suitable gearing. The electro-magnets actuated stylographic pens feeding red ink. One of the pens was actuated by a clock, making a contact every five seconds. Another was actuated by the air meter, a wiper making contact with the teeth of one of the gear wheels in the recording mechanism and each contact representing about

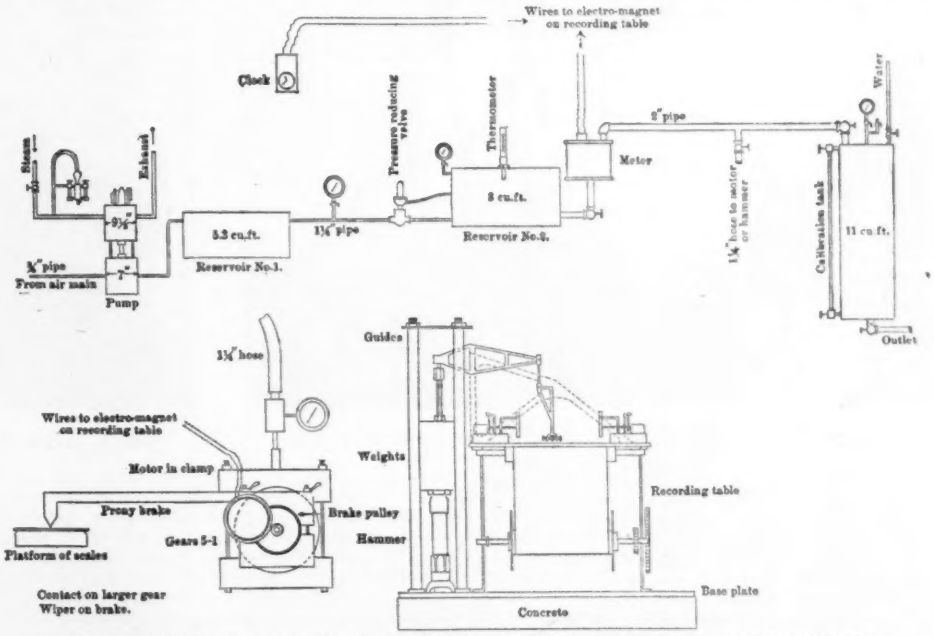


FIG. 1. DIAGRAM OF APPARATUS FOR TESTING AIR-MOTORS AND AIR-HAMMERS.

¼-cu. ft. of air. The third pen was used to record the revolutions of the motors by arranging a wiper and a simple gearing, so as to make a contact every 5 revolutions of the socket for holding the drill.

In calibrating the meter the method was to have the calibration tank about full of water, the valve from the meter opened up, thus allowing full pressure; the outlet valve was opened, the record paper started going and as the water in the gage glass passed the marks 5 ins. apart record was made by the observer pressing a push button. The meter at the same time made its own record, and thus we were able to figure out the number of cubic feet per contact or per notch. We also obtained record of 5-second intervals. As the readings of the meter varied somewhat with different rates of flow, calibrations were made at different rates by varying the opening at the outlet valve. A calibration curve was then made by plotting notches per minute as abscissæ and cubic feet per notch as ordinates. A number of calibration tests were made during the course of the tests of the tools.

The various gages used from which pressure readings

*A paper presented before the American Society of Mechanical Engineers at its annual meeting at New York, December, 1903.

†Engineer of Tests, C., B. & Q. Ry., Aurora, Ill.

TABLE I.—Sample of Data-Sheet for Tests of Air Motors.

Maker: Air Tool Co. Name of Tool: Mendota. Size: 3. Type: 3-cylinder.
Weight: 47 lbs. Serial No.: 82. Cost: $.....
Remarks: .....
Brake Lever Arm: 3 ft.
Date: 8/4-03. Temperature Atmosphere: 87 degs.

	A.	B.	C.	D.	E.	F.	G.	H.	I.
1. Pressure in reservoir, lbs. per sq. in.	101.0	101.0	101.0	101.0	121.0	121.0	121.0	121.0	121.0
2. Pressure at tool, lbs. per sq. in.	100.0	100.0	100.0	100.0	120.0	120.0	120.0	120.0	120.0
3. Tempr. comp. air, degs. F.	101.0	102.0	102.0	103.0	106.0	108.0	110.0	112.0	114.0
4. Notches per minute	24.0	21.2	19.3	17.6	23.4	24.0	20.0	20.3	17.5
5. Cubic feet per notch	0.262	0.264	0.263	0.266	0.263	0.262	0.264	0.264	0.266
6. Compressed air, cu. ft. per min.	6.8	5.6	5.2	4.7	6.2	6.8	5.3	5.4	4.6
7. Free air, cu. ft. per min.	52.0	42.8	40.0	36.0	56.0	61.3	48.0	47.7	41.3
8. Revolutions per min.	138.0	119.0	89.0	72.0	135.0	115.0	91.0	88.0	78.0
9 Weight on scale.	20.0	25.0	30.0	35.0	25.0	30.0	35.0	40.0	45.0
10. Brake horse-power	1.57	1.7	1.52	1.45	1.92	1.97	1.82	2.02	2.0
11. Stalling weight	.....	.....	.....	37.0	.....	.....	.....	.....	48.0
12. Stalling weight at 1-ft. radius	.....	.....	.....	111.0	.....	.....	.....	.....	48.0
13. Free air, cu. ft. per min. per HP.	33.0	25.0	26.0	24.8	29.0	31.0	26.5	23.5	20.7

(Signed).....
Observer.

TABLE II.—Sample Data-Sheet for Tests of Air Hammers.

Maker: Air Tool Co. Name of Tool: Vulcan. Size: 8.
Weight: 22 lbs. Serial No.: 3171. Co-t: $....
W't plunger: 1 lb. Diam. cyl.: 1 1/16 ins. Stroke: 8"
Remarks: .....
Date: 7/22-03. Temperature Atmosphere: 87 degs.

	A.	B.	C.	D.
1. Press. in reservoir, lbs.	60.0	80.0	100.0	120.0
2. Press. at tools, lbs.	60.0	80.0	100.0	120.0
3. Temp. comp. air, degs. F.	88.0	90.0	90.0	91.0
4. Notches per min.	29.0	24.0	25.0	21.0
5. Cu. ft. per notch	0.271	0.269	0.27	0.268
6. Comp. air, cu. ft. a min.	7.85	6.45	6.75	5.63
7. Free air, cu. ft. per min.	39.2	40.8	51.6	50.6
8. Strokes per min	834.0	892.0	964.0	1,000.0
9. Weight	120.0	120.0	120.0	120.0
10. Distance raised, ft	0.004	0.0052	0.006	0.007
11. Ft.-lbs. per blow	0.48	0.624	0.72	0.782
12 Horse-power	0.0122	0.0168	0.021	0.024
13. Free air, cu.ft. per min. per HP.	3,200	2,400	2.400	2,100

(Signed).....
Observer.

were taken were previously checked up and adjusted by means of a Crosby Dead Weight Tester.

MOTOR TESTS AND CALCULATIONS.

The arrangement used for testing motors is also shown in Fig. 1 and in the photograph, Fig. 2. The arrangement was to apply the load by means of a Prony friction brake, the revolutions being recorded by means of a wiper making contact every five revolutions. The air consumption and time were recorded as described above.

The procedure was to first regulate the pressure in reservoir No. 2 at 60 lbs., then put on a light brake load, keeping this constant during the test with full open throttle. Another test was then made with heavier brake load with the same air pressure, and the increments of load continued in successive tests till the tool was stalled. Then air pressures of 80, 100 and 120 lbs. were used in the same manner.

Table No. I. shows a sample data sheet, and the various items and calculations were obtained as follows:

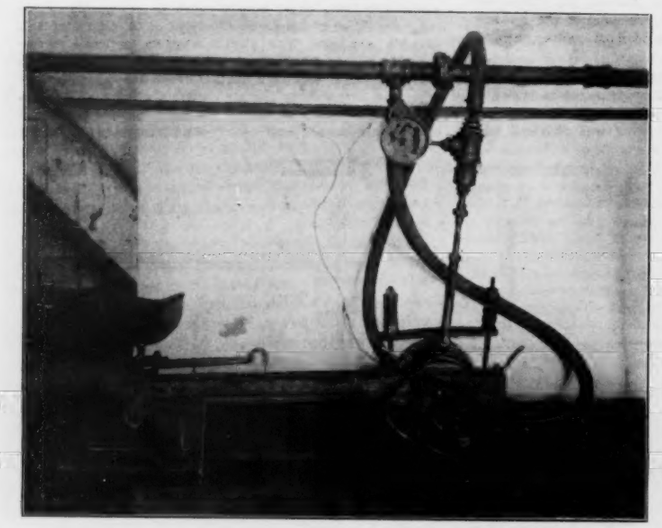


FIG. 2. VIEW OF APPARATUS FOR TESTING AIR MOTORS.

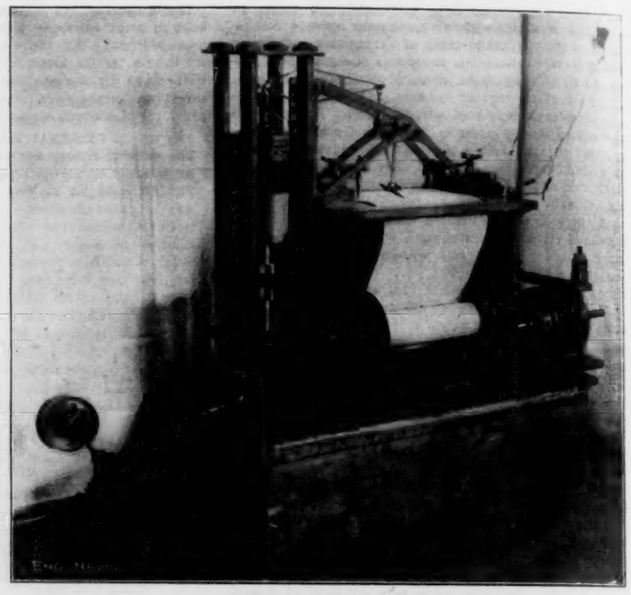


FIG. 3. VIEW OF APPARATUS FOR TESTING AIR-HAMMERS.

1 and 2 are pressures as read by an observer on gages and are pressures above atmospheric pressure.

3 is temperature in degrees Fahrenheit of the compressed air in reservoir No. 2.

4 is the meter contacts or notches obtained from the autographic record included in a strip of record covering one minute as recorded by the clock.

5 is the cubic feet of compressed air per meter notch as obtained from the calibration chart.

6 is the cubic feet of compressed air per minute obtained by multiplying 4 and 5.

7 is the number of cubic feet of free air per minute obtained from 6 by the following formula:

$$F\ A = \frac{C\ A \times (P + 15)}{15}$$

where F A = free air in cubic feet per minute.
C A = compressed air in cubic feet per minute.
P = pounds gage pressure at tool.

8 is the revolutions per minute of socket for holding the drill and is obtained from the autographic record.

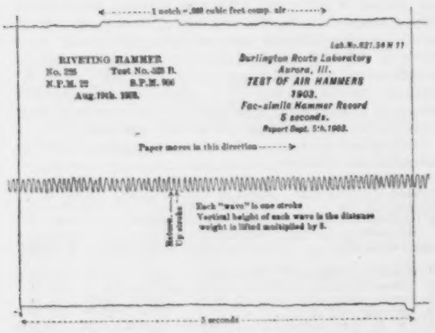

1 notch = .500 cubic feet comp. air
Lab. No. 527-3 & W 11
RIVETING HAMMER.
No. 226 Test No. 525 B.
N.P.M. 22 S.P.M. 906
Aug. 19th, 1903.
Burlington Route Laboratory
Aurora, Ill.
TEST OF AIR HAMMERS
1903.
Fac-simile Hammer Record
5 seconds.
Report Dept. 7-8, 1903.
Paper moves in this direction
Each "wave" is one stroke
Vertical height of each wave is the distance weight is lifted multiplied by 5.
Relative Up motion
5 seconds

Fig. 4. Sample Record of Air-Hammer Test.

9 is the brake load as shown by the weight on the scale at the end of the lever arm, usually 3 ft., except with the smaller motors, where the lever arm was 2 ft. This brake load was pre-determined and kept constant by an observer during each test.

10 is the brake horse-power, and was calculated as per following formula:

$$B.\ HP. = \frac{r\ p.\ m. \times 2r \times 3.1416 \times w}{33{,}000}$$

where B. HP. = brake horse-power.
r. p. m. = revolutions per minute of brake-wheel.
r = radius of brake-lever, in ft.
w = weight in pounds on scale.

11 is the load on scale which was just sufficient to stall the tool.

12 is the stalling load at 1 ft. radius calculated from the preceding item.

13 is the cubic feet of free air consumed per minute per horse-power, obtained by dividing item 7 by item 10.

After obtaining these various data we plotted three curve sheets to show up the results by the graphic method, representing in each case the air pressure as abscissæ. On one we plotted as ordinates the stalling load at 1 ft. radius, on another the air consumption in cubic feet of free air per minute per horse-power at maximum horse-power, and on the other the maximum horse-power.

AIR HAMMER TESTS AND CALCULATIONS.

The arrangements for testing air hammers is also shown in Fig. 1 and photograph, Fig. 3. The method in general was to let the hammer strike upward against a known weight adjusted to the size of the hammer and to autographically record the distance the weight was lifted. The weights varied from about 40 to 150 pounds, and the vertical lift was multiplied 8 times on the record. The time and air consumption were recorded as above described, and a fac-simile of one of the records obtained is shown in Fig. 4.

The results of test were recorded on a blank. A sample test record is shown in Table II. The various items in this table are as follows:

1 and 2 are gage-pressure readings, as noted by an observer.

3 is the temperature in degrees Fahrenheit of the compressed air in reservoir No. 2, as noted by an observer.

4 is the meter contacts or notches per minute as obtained from the autographic record.

5 is the cubic feet of compressed air per minute obtained tained from the calibration chart.

6 is the cubic feet of compressed air per minute obtained by multiplying items 4 and 5.

7 is the cubic feet of free air per minute obtained by the same formula as given under air motors.

8 is the number of strokes per minute obtained from the record by counting the strokes made in one minute.

9 is the pounds of the weight placed over the hammer.

10 is the average distance in feet the weight was raised as obtained from the record.

11 is the foot pounds of effective work per blow, obtained by multiplying the weight in pounds by the distance in feet it was raised.

12 is the horse-power of the hammer, obtained as per following formula:

$$H\ P = \frac{ft.\ lbs \times blows\ per\ min.}{33{,}000}$$

13 is the cubic feet of free air per minute per horse-power.

After obtaining the results of test, three curves were plotted from them as follows, in each case the pounds gage pressure being plotted as abscissæ and the following as ordinates: Foot pounds per blow, cubic feet of free air per minute per horse-power and horse-power.

In conclusion, the author desires to express his special thanks and acknowledgments to Mr. H. F. Wardwell, who did the greater part of the work in making the designs and tests.

A REPORT FAVORING PIER EXTENSION on the North River, at New York city, has been made by Mr. Samuel Whinery, M. Am. Soc. C. E., to the Commissioner of Docks. The report favors an extension of the pier line about 200 ft. so as to permit the building of piers 1,000 ft. long. The War Department objected to the original application of the Commissioner of Docks for permission to extend the pier line, and Mr. Whinery was called in by the Dock Commissioner to report on the engineering features of the project. It is stated in the daily papers that General Gillespie, Chief of Engineers, has submitted to the Secretary of War, a counter report, answering Mr. Whinery's arguments in favor of dock extension. The channel is now 2,700 ft. wide and to narrow it by even 200 ft. is regarded by General Gillespie as a menace to navigation. Mr. Whinery proposes, however, that the pier line on the New Jersey shore be moved inland 200 ft., and that dredging be done to carry the New Jersey docks to a sufficient length. General Gillespie, however, does not see how New York can justly ask to have 200 ft. added without giving an equal addition of 200 ft. to New Jersey, which would result in narrowing the channel to 2,300 ft.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear collision which occurred on the Boston & Albany R. R. at Worcester, Mass., on Dec. 6. A west-bound passenger train ran into the rear of a freight train which was standing in the yard, and crushed the caboose of the freight, killing three men who were asleep in it.

A LEAK IN THE RAPID TRANSIT TUNNEL under the East River has caused temporary stoppage of work at the Manhattan end. This is a twin tube tunnel and the break occurred in the southernmost of the two tubes, which was flooded to a depth of about 10 ft. The work on the tunnel from the Manhattan end has so far been through rock, and as nearly as can be told the leak was caused by a blast breaking into a crevice which connected with the river. It is now proposed to put on air pressure, a plant for which was long ago provided for exactly this purpose, and after pumping out the water to proceed with the work.

CHICAGO RAILWAY ACCIDENTS in November resulted in 42 deaths; of these, 2 were in accidents on elevated railways, 9 on electric lines, 4 on cable lines, and 27 on steam lines, most of the latter being at grade crossings. During the month about one-third of the street railway system was tied up for nearly two weeks by a strike. There were 98 minor acidents on the street railways, and 105 persons were injured on the electric lines.

TOPOGRAPHIC MAPS OF THE SANDUSKY QUADrangle, Ohio, are now ready for distribution by the U. S. Geographical Survey. The quadrangle comprises Erie and Huron counties and contains about 230 sq. miles.